ANALYST'S LABORATORY COMPANION

THE ANALYST'S

LABORATORY COMPANION:

A COLLECTION OF TABLES AND DATA FOR THE USE OF PUBLIC AND GENERAL ANALYSTS, AGRICULTURAL, BREWERS', AND WORKS' CHEMISTS, AND STUDENTS; TOGETHER WITH NUMEROUS EXAMPLES OF CHEMICAL CALCULATIONS AND CONCISE DESCRIPTIONS OF SEVERAL ANALYTICAL PROCESSES

BY

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FOURTH EDITION
(THOROUGHLY REVISED, WITH ADDITIONS)

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PREFACE TO THE FOURTH EDITION.

In this Edition I have adopted the International Atomic Weights for 1912, and have accordingly entirely re-calculated the gravimetric and volumetric factors, percentage compositions of commonly occurring compounds, etc. In all cases the full molecular weights, without any reduction, and seven-figure logarithms were used, the logarithms being finally reduced to five figures, which are sufficient for all practical purposes. The above-mentioned tables have been considerably amplified; and the gravimetric and volumetric factors have been printed in larger type than heretofore, so as to secure greater ease and certainty in reference.

The section devoted to Weights and Measures has been entirely re-written in accordance with the most recent legislation on the subject. It should be noted that the legal Imperial Weights and Measures and the Imperial equivalents of Metric Weights and Measures are authorized, from time to time, by various "Orders in Council." Several useful approximations have been added. I have pleasure in recording my thanks to Major P. A. MacMahon, F.R.S., the Deputy Warden of the Standards, for assistance kindly rendered in this section.

In the Water and Sewage section I have given a much fuller account of the determination of nitrates by the phenol-disulphonic acid method, which I have had in use for the past twenty-eight years; also an epitome of Chamot, Pratt, and Redfield's method of procedure. I made some comments on the latter in *The Chemical News*, 1911, **104**, 235.

The section dealing with specific rotatory power and cupric reducing power of the carbohydrates has again been thoroughly revised, and, I believe, brought up to date. I am indebted to Dr. E. Frankland Armstrong for kindly examining my revise of this portion of the book.

The Kjeldahl table has been re-calculated and extended.

The tables of constants of oils, fats, and waxes have been thoroughly revised.

Several new tables have been added, amongst which may be mentioned the following:—

The melting points of metals, the coefficients of absorption of gases in water, standards for sewage effluents, amounts of dissolved oxygen in distilled water, tables showing the deficiencies both in non-fatty solids and in fat in milks in which these are below the minima allowed, the principal provisions of the recently issued Draft of "The Public Health (Milk and Cream) Regulations, 1912," etc.

It should be stated that in all cases where a factor does not exactly correspond to a seven-figure logarithm, the logarithm should be used where the highest accuracy is desired.

A. E. JOHNSON.

24 Parkdale, Wolverhampton,
May 1912.

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CORRIGENDUM.

Page 23, line 13 from bottom, *for* $\bar{2}\cdot 92436$, *read* $\bar{2}\cdot 92432$.

THE
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THE INTERNATIONAL ATOMIC WEIGHTS FOR 1912
(USED THROUGHOUT THIS WORK).

		O=16.			O=16.
Aluminium	Al	27·1	Molybdenum	Mo	96
Antimony	Sb	120·2	Neodymium	Nd	144·3
Argon	A	39·88	Neon	Ne	20·2
Arsenic	As	74·96	Nickel	Ni	58·68
Barium	Ba	137·37	Niton (radium emanation)	Nt	222·4
Bismuth	Bi	208	Nitrogen	N	14·01
Boron	B	11	Osmium	Os	190·9
Bromine	Br	79·92	Oxygen	O	16
Cadmium	Cd	112·4	Palladium	Pd	106·7
Cæsium	Cs	132·81	Phosphorus	P	31·04
Calcium	Ca	40·07	Platinum	Pt	195·2
Carbon	C	12	Potassium	K	39·1
Cerium	Ce	140·25	Praseodymium	Pr	140·6
Chlorine	Cl	35·46	Radium	Ra	226·4
Chromium	Cr	52	Rhodium	Rh	102·9
Cobalt	Co	58·97	Rubidium	Rb	85·45
Columbium	Cb	93·5	Ruthenium	Ru	101·7
Copper	Cu	63·57	Samarium	Sa	150·4
Dysprosium	Dy	162·5	Scandium	Sc	44·1
Erbium	Er	167·7	Selenium	Se	79·2
Europium	Eu	152	Silicon	Si	28·3
Fluorine	F	19	Silver	Ag	107·88
Gadolinium	Gd	157·3	Sodium	Na	23
Gallium	Ga	69·9	Strontium	Sr	87·63
Germanium	Ge	72·5	Sulphur	S	32·07
Glucinum	Gl	9·1	Tantalum	Ta	181·5
Gold	Au	197·2	Tellurium	Te	127·5
Helium	He	3·99	Terbium	Tb	159·2
Hydrogen	H	1·008	Thallium	Tl	204
Indium	In	114·8	Thorium	Th	232·4
Iodine	I	126·92	Thulium	Tm	168·5
Iridium	Ir	193·1	Tin	Sn	119
Iron	Fe	55·84	Titanium	Ti	48·1
Krypton	Kr	82·92	Tungsten	W	184
Lanthanum	La	139	Uranium	U	238·5
Lead	Pb	207·1	Vanadium	V	51
Lithium	Li	6·94	Xenon	Xe	130·2
Lutecium	Lu	174	Ytterbium (Neoytterbium)	Yb	172
Magnesium	Mg	24·32	Yttrium	Yt	89
Manganese	Mn	54·93	Zinc	Zn	65·37
Mercury	Hg	200·6	Zirconium	Zr	90·6

COMMON LOGARITHMS.

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
10	0	00432	00860	01284	01703	02119	02531	02938	03342	03743									
11	04139	04532	04922	05308	05690	06070	06446	06819	07188	07555									
12	07918	08279	08636	08991	09342	09691	10037	10380	10721	11059									
13	11394	11727	12057	12385	12710	13033	13354	13672	13988	14301									
14	14613	14922	15229	15534	15836	16137	16435	16732	17026	17319									
15	17609	17898	18184	18469	18752	19033	19312	19590	19866	20140									
16	20412	20683	20952	21219	21484	21748	22011	22272	22531	22789									
17	23045	23300	23553	23805	24055	24304	24551	24797	25042	25285									
18	25527	25768	26007	26245	26482	26717	26951	27184	27416	27646									
19	27875	28103	28330	28556	28780	29003	29226	29447	29667	29885									
20	30103	30320	30535	30750	30963	31175	31387	31597	31806	32015	21	42	64	85	106	127	148	170	191
21	32222	32428	32634	32838	33041	33244	33445	33646	33846	34044	20	40	61	81	101	121	141	162	182
22	34242	34439	34635	34830	35025	35218	35411	35603	35793	35984	19	39	58	77	97	116	135	154	174
23	36173	36361	36549	36736	36922	37107	37291	37475	37658	37840	18	37	55	74	92	111	129	148	166
24	38021	38202	38382	38561	38739	38917	39094	39270	39445	39620	18	35	53	71	89	106	124	142	160
25	39794	39967	40140	40312	40483	40654	40824	40993	41162	41330	17	34	51	68	85	102	119	136	153
26	41497	41664	41830	41996	42160	42325	42488	42651	42813	42975	16	33	49	66	82	98	115	131	148
27	43136	43297	43457	43616	43775	43933	44091	44248	44404	44560	16	32	47	63	79	95	111	126	142
28	44716	44871	45025	45179	45332	45484	45637	45788	45939	46090	15	30	46	61	76	91	107	122	137
29	46240	46389	46538	46687	46835	46982	47129	47276	47422	47567	15	29	44	59	74	88	103	118	132

COMMON LOGARITHMS—(*continued*).

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
30	47712	47857	48001	48144	48287	48430	48572	48714	48855	48996	14	28	43	57	71	85	100	114	128
31	49136	49276	49415	49554	49693	49831	49969	50106	50243	50379	14	28	41	55	69	83	97	110	124
32	50515	50651	50786	50920	51055	51188	51322	51455	51587	51720	13	27	40	53	67	80	94	107	120
33	51851	51983	52114	52244	52375	52504	52634	52763	52892	53020	13	26	39	52	65	78	91	104	117
34	53148	53275	53403	53529	53656	53782	53908	54033	54158	54283	13	25	38	50	63	76	88	101	113
35	54407	54531	54654	54777	54900	55023	55145	55267	55388	55509	12	24	37	49	61	73	86	98	110
36	55630	55751	55871	55991	56110	56229	56348	56467	56585	56703	12	24	36	48	59	71	83	95	107
37	56820	56937	57054	57171	57287	57403	57519	57634	57749	57864	12	23	35	46	58	69	81	93	104
38	57978	58092	58206	58320	58433	58546	58659	58771	58883	58995	11	23	34	45	56	68	79	90	102
39	59106	59218	59329	59439	59550	59660	59770	59879	59988	60097	11	22	33	44	55	66	77	88	99
40	60206	60314	60423	60531	60638	60746	60853	60959	61066	61172	11	21	32	43	54	64	75	86	97
41	61278	61384	61490	61595	61700	61805	61909	62014	62118	62221	10	21	31	42	52	63	73	84	94
42	62325	62428	62531	62634	62737	62839	62941	63043	63144	63246	10	20	31	41	51	61	72	82	92
43	63347	63448	63548	63649	63749	63849	63949	64048	64147	64246	10	20	30	40	50	60	70	80	90
44	64345	64444	64542	64640	64738	64836	64933	65031	65128	65225	10	20	29	39	49	59	68	78	88
45	65321	65418	65514	65610	65706	65801	65896	65992	66087	66181	10	19	29	38	48	57	67	76	86
46	66276	66370	66464	66558	66652	66745	66839	66932	67025	67117	9	19	28	37	47	56	65	75	84
47	67210	67302	67394	67486	67578	67669	67761	67852	67943	68034	9	18	27	37	46	55	64	73	82
48	68124	68215	68305	68395	68485	68574	68664	68753	68842	68931	9	18	27	36	45	54	63	72	81
49	69020	69108	69197	69285	69373	69461	69548	69636	69723	69810	9	18	26	35	44	53	61	70	79

Note.—The tabular logs. of numbers 1 to 10 are the same as those of 10, 20, 30, etc.

COMMON LOGARITHMS—(*continued*).

	0	1	2	3	4	5	6	7	8	9	1 2 3	4 5 6	7 8 9
50	69897	69984	70070	70157	70243	70329	70415	70501	70586	70672	9 17 26	34 43 52	60 69 77
51	70757	70842	70927	71012	71096	71181	71265	71349	71433	71517	8 17 25	34 42 51	59 67 76
52	71600	71684	71767	71850	71933	72016	72099	72181	72263	72346	8 17 25	33 41 50	58 66 74
53	72428	72509	72591	72673	72754	72835	72916	72997	73078	73159	8 16 24	32 41 49	57 65 73
54	73239	73320	73400	73480	73560	73640	73719	73799	73878	73957	8 16 24	32 40 48	56 64 72
55	74036	74115	74194	74273	74351	74429	74507	74586	74663	74741	8 16 23	31 39 47	55 63 70
56	74819	74896	74974	75051	75128	75205	75282	75358	75435	75511	8 15 23	31 38 46	54 61 69
57	75587	75664	75740	75815	75891	75967	76042	76118	76193	76268	8 15 23	30 38 45	53 60 68
58	76343	76418	76492	76567	76641	76716	76790	76864	76938	77012	7 15 22	30 37 45	52 59 67
59	77085	77159	77232	77305	77379	77452	77525	77597	77670	77743	7 15 22	29 36 44	51 58 66
60	77815	77887	77960	78032	78104	78176	78247	78319	78390	78462	7 14 22	29 36 43	50 57 65
61	78533	78604	78675	78746	78817	78888	78958	79029	79099	79169	7 14 21	28 35 42	49 56 64
62	79239	79309	79379	79449	79518	79588	79657	79727	79796	79865	7 14 21	28 35 42	49 56 63
63	79934	80003	80072	80140	80209	80277	80346	80414	80482	80550	7 14 21	27 34 41	48 55 62
64	80618	80686	80754	80821	80889	80956	81023	81090	81158	81224	7 13 20	27 34 40	47 54 61
65	81291	81358	81425	81491	81558	81624	81690	81757	81823	81889	7 13 20	27 33 40	46 53 60
66	81954	82020	82086	82151	82217	82282	82347	82413	82478	82543	7 13 20	26 33 39	46 52 59
67	82607	82672	82737	82802	82866	82930	82995	83059	83123	83187	6 13 19	26 32 39	45 51 58
68	83251	83315	83378	83442	83506	83569	83632	83696	83759	83822	6 13 19	25 32 38	44 51 57
69	83885	83948	84011	84073	84136	84198	84261	84323	84386	84448	6 12 19	25 31 37	44 50 56

COMMON LOGARITHMS—(*continued*).

	0	1	2	3	4	5	6	7	8	9	1 2 3	4 5 6	7 8 9
70	84510	84572	84634	84696	84757	84819	84880	84942	85003	85065	6 12 18	25 31 37	43 49 55
71	85126	85187	85248	85309	85370	85431	85491	85552	85612	85673	6 12 18	24 30 36	43 49 55
72	85733	85794	85854	85914	85974	86034	86094	86153	86213	86273	6 12 18	24 30 36	42 48 54
73	86332	86392	86451	86510	86570	86629	86688	86747	86806	86864	6 12 18	24 30 35	41 47 53
74	86923	86982	87040	87099	87157	87216	87274	87332	87390	87448	6 12 17	23 29 35	41 47 52
75	87506	87564	87622	87679	87737	87795	87852	87910	87967	88024	6 12 17	23 29 35	40 46 52
76	88081	88138	88195	88252	88309	88366	88423	88480	88536	88593	6 11 17	23 28 34	40 45 51
77	88649	88705	88762	88818	88874	88930	88986	89042	89098	89154	6 11 17	22 28 34	39 45 50
78	89209	89265	89321	89376	89432	89487	89542	89597	89653	89708	6 11 17	22 28 33	39 44 50
79	89763	89818	89873	89927	89982	90037	90091	90146	90200	90255	5 11 16	22 27 33	38 44 49
80	90309	90363	90417	90472	90526	90580	90634	90687	90741	90795	5 11 16	22 27 32	38 43 49
81	90849	90902	90956	91009	91062	91116	91169	91222	91275	91328	5 11 16	21 27 32	37 43 48
82	91381	91434	91487	91540	91593	91645	91698	91751	91803	91855	5 11 16	21 26 32	37 42 47
83	91908	91960	92012	92065	92117	92169	92221	92273	92324	92376	5 10 16	21 26 31	36 42 47
84	92428	92480	92531	92583	92634	92686	92737	92788	92840	92891	5 10 15	21 26 31	36 41 46
85	92942	92993	93044	93095	93146	93197	93247	93298	93349	93399	5 10 15	20 25 30	36 41 46
86	93450	93500	93551	93601	93651	93702	93752	93802	93852	93902	5 10 15	20 25 30	35 40 45
87	93952	94002	94052	94101	94151	94201	94250	94300	94349	94399	5 10 15	20 25 30	35 40 45
88	94448	94498	94547	94596	94645	94694	94743	94792	94841	94890	5 10 15	20 25 29	34 39 44
89	94939	94988	95036	95085	95134	95182	95231	95279	95328	95376	5 10 15	19 24 29	34 39 44

COMMON LOGARITHMS—(*continued*).

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
90	95424	95472	95521	95569	95617	95665	95713	95761	95809	95856	5	10	14	19	24	29	34	38	43
91	95904	95952	95999	96047	96095	96142	96190	96237	96284	96332	5	9	14	19	24	28	33	38	43
92	96379	96426	96473	96520	96567	96614	96661	96708	96755	96802	5	9	14	19	23	28	33	38	42
93	96848	96895	96942	96988	97035	97081	97128	97174	97220	97267	5	9	14	19	23	28	33	37	42
94	97313	97359	97405	97451	97497	97543	97589	97635	97681	97727	5	9	14	18	23	28	32	37	41
95	97772	97818	97864	97909	97955	98000	98046	98091	98137	98182	5	9	14	18	23	27	32	36	41
96	98227	98272	98318	98363	98408	98453	98498	98543	98588	98632	5	9	14	18	23	27	32	36	41
97	98677	98722	98767	98811	98856	98900	98945	98989	99034	99078	4	9	13	18	22	27	31	36	40
98	99123	99167	99211	99255	99300	99344	99388	99432	99476	99520	4	9	13	18	22	26	31	35	40
99	99564	99607	99651	99695	99739	99782	99826	99870	99913	99957	4	9	13	17	22	26	31	35	39
100	0	00043	00087	00130	00173	00217	00260	00303	00346	00389	4	9	13	17	22	26	30	35	39
101	00432	00475	00518	00561	00604	00647	00689	00732	00775	00817	4	9	13	17	21	26	30	34	39
102	00860	00903	00945	00988	01030	01072	01115	01157	01199	01242	4	8	13	17	21	25	30	34	38
103	01284	01326	01368	01410	01452	01494	01536	01578	01620	01662	4	8	13	17	21	25	29	34	38
104	01703	01745	01787	01828	01870	01912	01953	01995	02036	02078	4	8	12	17	21	25	29	33	37
105	02119	02160	02202	02243	02284	02325	02366	02407	02449	02490	4	8	12	16	21	25	29	33	37
106	02531	02572	02612	02653	02694	02735	02776	02816	02857	02898	4	8	12	16	20	24	29	33	37
107	02938	02979	03019	03060	03100	03141	03181	03222	03262	03302	4	8	12	16	20	24	28	32	36
108	03342	03383	03423	03463	03503	03543	03583	03623	03663	03703	4	8	12	16	20	24	28	32	36
109	03743	03782	03822	03862	03902	03941	03981	04021	04060	04100	4	8	12	16	20	24	28	32	36

COMMON LOGARITHMS—(*continued*).

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
110	04139	04179	04218	04258	04297	04336	04376	04415	04454	04493	4	8	12	16	20	24	28	31	35
111	04532	04571	04610	04650	04689	04727	04766	04805	04844	04883	4	8	12	16	19	23	27	31	35
112	04922	04961	04999	05038	05077	05115	05154	05192	05231	05269	4	8	12	15	19	23	27	31	35
113	05308	05346	05385	05423	05461	05500	05538	05576	05614	05652	4	8	11	15	19	23	27	31	34
114	05690	05729	05767	05805	05843	05881	05918	05956	05994	06032	4	8	11	15	19	23	27	30	34
115	06070	06108	06145	06183	06221	06258	06296	06333	06371	06408	4	8	11	15	19	23	26	30	34
116	06446	06483	06521	06558	06595	06633	06670	06707	06744	06781	4	7	11	15	19	22	26	30	34
117	06819	06856	06893	06930	06967	07004	07041	07078	07115	07151	4	7	11	15	18	22	26	30	33
118	07188	07225	07262	07298	07335	07372	07408	07445	07482	07518	4	7	11	15	18	22	26	29	33
119	07555	07591	07628	07664	07700	07737	07773	07809	07846	07882	4	7	11	15	18	22	25	29	33
120	07918	07954	07990	08027	08063	08099	08135	08171	08207	08243	4	7	11	14	18	22	25	29	32
121	08279	08314	08350	08386	08422	08458	08493	08529	08565	08600	4	7	11	14	18	21	25	29	32
122	08636	08672	08707	08743	08778	08814	08849	08884	08920	08955	4	7	11	14	18	21	25	28	32
123	08991	09026	09061	09096	09132	09167	09202	09237	09272	09307	4	7	11	14	18	21	25	28	32
124	09342	09377	09412	09447	09482	09517	09552	09587	09621	09656	3	7	10	14	17	21	24	28	31
125	09691	09726	09760	09795	09830	09864	09899	09934	09968	10003	3	7	10	14	17	21	24	28	31
126	10037	10072	10106	10140	10175	10209	10243	10278	10312	10346	3	7	10	14	17	21	24	27	31
127	10380	10415	10449	10483	10517	10551	10585	10619	10653	10687	3	7	10	14	17	20	24	27	31
128	10721	10755	10789	10823	10857	10890	10924	10958	10992	11025	3	7	10	14	17	20	24	27	30
129	11059	11093	11126	11160	11193	11227	11261	11294	11327	11361	3	7	10	13	17	20	23	27	30

COMMON LOGARITHMS—*(continued)*.

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
130	11394	11428	11461	11494	11528	11561	11594	11628	11661	11694	3	7	10	13	17	20	23	27	30
131	11727	11760	11793	11826	11860	11893	11926	11959	11992	12024	3	7	10	13	17	20	23	26	30
132	12057	12090	12123	12156	12189	12222	12254	12287	12320	12352	3	7	10	13	16	20	23	26	29
133	12385	12418	12450	12483	12516	12548	12581	12613	12646	12678	3	7	10	13	16	20	23	26	29
134	12710	12743	12775	12808	12840	12872	12905	12937	12969	13001	3	6	10	13	16	19	23	26	29
135	13033	13066	13098	13130	13162	13194	13226	13258	13290	13322	3	6	10	13	16	19	22	26	29
136	13354	13386	13418	13450	13481	13513	13545	13577	13609	13640	3	6	10	13	16	19	22	25	29
137	13672	13704	13735	13767	13799	13830	13862	13893	13925	13956	3	6	9	13	16	19	22	25	28
138	13988	14019	14051	14082	14114	14145	14176	14208	14239	14270	3	6	9	13	16	19	22	25	28
139	14301	14333	14364	14395	14426	14457	14489	14520	14551	14582	3	6	9	12	16	19	22	25	28
140	14613	14644	14675	14706	14737	14768	14799	14829	14860	14891	3	6	9	12	15	19	22	25	28
141	14922	14953	14983	15014	15045	15076	15106	15137	15168	15198	3	6	9	12	15	18	21	25	28
142	15229	15259	15290	15320	15351	15381	15412	15442	15473	15503	3	6	9	12	15	18	21	24	27
143	15534	15564	15594	15625	15655	15685	15715	15746	15776	15806	3	6	9	12	15	18	21	24	27
144	15836	15866	15897	15927	15957	15987	16017	16047	16077	16107	3	6	9	12	15	18	21	24	27
145	16137	16167	16197	16227	16256	16286	16316	16346	16376	16406	3	6	9	12	15	18	21	24	27
146	16435	16465	16495	16524	16554	16584	16613	16643	16673	16702	3	6	9	12	15	18	21	24	27
147	16732	16761	16791	16820	16850	16879	16909	16938	16967	16997	3	6	9	12	15	18	21	24	26
148	17026	17056	17085	17114	17143	17173	17202	17231	17260	17289	3	6	9	12	15	18	20	23	26
149	17319	17348	17377	17406	17435	17464	17493	17522	17551	17580	3	6	9	12	15	17	20	23	26

COMMON LOGARITHMS—*(continued)*.

	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
150	17609	17638	17667	17696	17725	17754	17782	17811	17840	17869	3	6	9	12	14	17	20	23	26
151	17898	17926	17955	17984	18013	18041	18070	18099	18127	18156	3	6	9	11	14	17	20	23	26
152	18184	18213	18241	18270	18298	18327	18355	18384	18412	18441	3	6	9	11	14	17	20	23	26
153	18469	18498	18526	18554	18583	18611	18639	18667	18696	18724	3	6	8	11	14	17	20	23	25
154	18752	18780	18808	18837	18865	18893	18921	18949	18977	19005	3	6	8	11	14	17	20	22	25
155	19033	19061	19089	19117	19145	19173	19201	19229	19257	19285	3	6	8	11	14	17	20	22	25
156	19312	19340	19368	19396	19424	19451	19479	19507	19535	19562	3	6	8	11	14	17	19	22	25
157	19590	19618	19645	19673	19700	19728	19756	19783	19811	19838	3	6	8	11	14	17	19	22	25
158	19866	19893	19921	19948	19976	20003	20030	20058	20085	20112	3	5	8	11	14	16	19	22	25
159	20140	20167	20194	20222	20249	20276	20303	20330	20358	20385	3	5	8	11	14	16	19	22	25
160	20412	20439	20466	20493	20520	20548	20575	20602	20629	20656	3	5	8	11	14	16	19	22	24
161	20683	20710	20737	20763	20790	20817	20844	20871	20898	20925	3	5	8	11	13	16	19	22	24
162	20952	20978	21005	21032	21059	21085	21112	21139	21165	21192	3	5	8	11	13	16	19	21	24
163	21219	21245	21272	21299	21325	21352	21378	21405	21431	21458	3	5	8	11	13	16	19	21	24
164	21484	21511	21537	21564	21590	21617	21643	21669	21696	21722	3	5	8	11	13	16	18	21	24
165	21748	21775	21801	21827	21854	21880	21906	21932	21958	21985	3	5	8	10	13	16	18	21	24
166	22011	22037	22063	22089	22115	22141	22167	22194	22220	22246	3	5	8	10	13	16	18	21	23
167	22272	22298	22324	22350	22376	22401	22427	22453	22479	22505	3	5	8	10	13	16	18	21	23
168	22531	22557	22583	22608	22634	22660	22686	22712	22737	22763	3	5	8	10	13	15	18	21	23
169	22789	22814	22840	22866	22891	22917	22943	22968	22994	23019	3	5	8	10	13	15	18	20	23

COMMON LOGARITHMS—*(continued)*.

	0	1	2	3	4	5	6	7	8	9	1 2 3	4 5 6	7 8 9
170	23045	23070	23096	23121	23147	23172	23198	23223	23249	23274	3 5 8	10 13 15	18 20 23
171	23300	23325	23350	23376	23401	23426	23452	23477	23502	23528	3 5 8	10 13 15	18 20 23
172	23553	23578	23603	23629	23654	23679	23704	23729	23754	23779	3 5 8	10 13 15	18 20 23
173	23805	23830	23855	23880	23905	23930	23955	23980	24005	24030	3 5 8	10 13 15	18 20 23
174	24055	24080	24105	24130	24155	24180	24204	24229	24254	24279	2 5 7	10 12 15	17 20 22
175	24304	24329	24353	24378	24403	24428	24452	24477	24502	24527	2 5 7	10 12 15	17 20 22
176	24551	24576	24601	24625	24650	24674	24699	24724	24748	24773	2 5 7	10 12 15	17 20 22
177	24797	24822	24846	24871	24895	24920	24944	24969	24993	25018	2 5 7	10 12 15	17 20 22
178	25042	25066	25091	25115	25139	25164	25188	25212	25237	25261	2 5 7	10 12 15	17 19 22
179	25285	25310	25334	25358	25382	25406	25431	25455	25479	25503	2 5 7	10 12 15	17 19 22
180	25527	25551	25575	25600	25624	25648	25672	25696	25720	25744	2 5 7	10 12 14	17 19 22
181	25768	25792	25816	25840	25864	25888	25912	25935	25959	25983	2 5 7	9 12 14	17 19 22
182	26007	26031	26055	26079	26102	26126	26150	26174	26198	26221	2 5 7	9 12 14	17 19 21
183	26245	26269	26293	26316	26340	26364	26387	26411	26435	26458	2 5 7	9 12 14	17 19 21
184	26482	26505	26529	26553	26576	26600	26623	26647	26670	26694	2 5 7	9 12 14	16 19 21
185	26717	26741	26764	26788	26811	26834	26858	26881	26905	26928	2 5 7	9 12 14	16 19 21
186	26951	26975	26998	27021	27045	27068	27091	27114	27138	27161	2 5 7	9 12 14	16 19 21
187	27184	27207	27231	27254	27277	27300	27323	27346	27370	27393	2 5 7	9 12 14	16 19 21
188	27416	27439	27462	27485	27508	27531	27554	27577	27600	27623	2 5 7	9 12 14	16 18 21
189	27646	27669	27692	27715	27738	27761	27784	27807	27830	27852	2 5 7	9 11 14	16 18 21

COMMON LOGARITHMS—*(continued)*.

	0	1	2	3	4	5	6	7	8	9	1 2 3	4 5 6	7 8 9
190	27875	27898	27921	27944	27967	27989	28012	28035	28058	28081	2 5 7	9 11 14	16 18 21
191	28103	28126	28149	28171	28194	28217	28240	28262	28285	28307	2 5 7	9 11 14	16 18 20
192	28330	28353	28375	28398	28421	28443	28466	28488	28511	28533	2 5 7	9 11 14	16 18 20
193	28556	28578	28601	28623	28646	28668	28691	28713	28735	28758	2 4 7	9 11 13	16 18 20
194	28780	28803	28825	28847	28870	28892	28914	28937	28959	28981	2 4 7	9 11 13	16 18 20
195	29003	29026	29048	29070	29092	29115	29137	29159	29181	29203	2 4 7	9 11 13	16 18 20
196	29226	29248	29270	29292	29314	29336	29358	29380	29403	29425	2 4 7	9 11 13	15 18 20
197	29447	29469	29491	29513	29535	29557	29579	29601	29623	29645	2 4 7	9 11 13	15 18 20
198	29667	29688	29710	29732	29754	29776	29798	29820	29842	29863	2 4 7	9 11 13	15 18 20
199	29885	29907	29929	29951	29973	29994	30016	30038	30060	30081	2 4 7	9 11 13	15 17 20

Base of Common Logarithms = 10.	Base of Hyperbolic Logarithms = e = 2·71828.
Hyp. Log. $x = \frac{1}{M}$ Com. Log. x.	Com. Log. x = M Hyp. Log. x.

Number.	Com. Log.	Number.	Com. Log.
e = 2·71828	0·434 2945	π = 3·14159	0·497 1499
$\frac{1}{M}$ = 2·30259	0·362 2157	$\frac{\pi}{4}$ = 0·785398	$\bar{1}$·895 0899
M = 0·434294	$\bar{1}$·637 7843	$\frac{\pi}{6}$ = 0·52359	$\bar{1}$·718 9986
		$\sqrt{\pi}$ = 1·77245	0·248 5749

Densities of Gases.

(*The observed Densities are given in this Table.*)

Name of Gas.	Formula.	Molecular Weight.	Weight of 1 litre at 0° C. and 760 mm. Bar.	Logarithms.	Observer.
			(grams.)		
Acetylene, . .	C_2H_2	26·016	1·189	0·075 1819	Berthelot
Ammonia, . .	NH_3	17·034	0·7708	$\bar{1}$·886 9417	Perman & Davies
Atmospheric air, .	...	...	1·2928	0·111 5313	Rayleigh
Carbon monoxide, .	CO	28	1·2504	0·097 0490	,,
,, dioxide, .	CO_2	44	1·9769	0·295 9847	,,
Chlorine, . .	Cl_2	70·92	3·2191	0·507 7345	Treadwell
Ethylene, . .	C_2H_4	28·032	1·2737	0·105 0671	Saussure
Hydrogen, . .	H_2	2·016	0·0899	$\bar{2}$·953 7597	Rayleigh
Hydrogen chloride,	HCl	36·468	1·6392	0·214 6319	Gray and Burt
,, sulphide,	H_2S	34·086	1·5378	0·186 8999	Leduc
Methane, . .	CH_4	16·032	0·7209	$\bar{1}$·857 8750	Thomson
Nitrogen, . .	N_2	28·02	1·2507	0·097 1531	Rayleigh, Gray
Nitrous oxide, .	N_2O	44·02	1·9777	0·296 1604	Rayleigh
Nitric oxide, . .	NO	30·01	1·3402	0·127 1696	Gray
,, peroxide, .	NO_2	46·01	2·0530*	0·312 3889	...
Oxygen, . .	O_2	32	1·4290	0·155 0822	Rayleigh
Sulphur dioxide, .	SO_2	64·07	2·9266	0·466 3684	Leduc and others

Note.—1·008 gram of hydrogen occupies 11·2125 litres at N.T.P. * Calculated.
1000 cubic feet of air at 62° F. weigh 76·08 lb.

Melting Points of Metals.

(*The Values marked * are by Prof. W. C. Roberts-Austen.*)

Metal.	Melting Point.	Metal.	Melting Point.
	° C.		° C.
Aluminium, . .	625*	Manganese, ...	1900
Antimony, . .	632	Mercury (B. P. 358° C.),	− 39
Bismuth, . .	270	Nickel, ...	1427
Cadmium, . .	320	Osmium, ...	2500
Cobalt, . . .	1500	Palladium, ...	1500*
Copper, . . .	1054*	Platinum,†	1775*
Gold, . . .	1045*	Potassium, ...	62·1
Iridium, . . .	1950	Silver, ...	954*
Iron (pig), . .	1100–1200	Sodium, ...	97·6
,, (wrought). .	1500–1600	Steel, ...	1300–1400
Lead, . . .	326*	Tin, ...	232
Lithium, . .	180	Zinc, ...	415*
Magnesium, . .	750		

† Dr Harker, F.R.S., of the National Physical Laboratory, gives 1710°.

Factors and their Logarithms required in Gravimetric Analysis.

Element.	To convert	Factor.	Logarithm (to be *added*).
	Aluminium ($Al = 27{\cdot}1$)		
Al	Al_2O_3 into Al_2	0·53033	$\bar{1}$·724 55
„	„ „ $Al_2(NH_4)_2(SO_4)_4$, $24H_2O$	8·87425	0·948 13
„	„ „ $Al_2K_2(SO_4)_4$, $24H_2O$	9·28634	0·967 84
„	$Al_2(PO_4)_2$ „ Al_2O_3	0·41837	$\bar{1}$·621 56
„	„ „ $Al_2(NH_4)_2(SO_4)_4$, $24H_2O$	3·71274	0·569 69
„	Ammonia-alum into Potash-alum	1·04644	0·019 71
	Ammonium (see under Nitrogen)		
	Antimony ($Sb = 120{\cdot}2$)		
Sb	Sb_2O_4 into Sb_2	0·78975	$\bar{1}$·897 49
„	Sb_2S_3 „ Sb_2	0·71418	$\bar{1}$·853 81
„	„ „ Sb_2O_4	0·90431	$\bar{1}$·956 32
	Arsenic ($As = 74{\cdot}96$)		
As	$2NH_4MgAsO_4$, H_2O into As_2	0·39384	$\bar{1}$·595 32
„	„ „ As_2O_3	0·51994	$\bar{1}$·715 95
„	„ „ As_2O_5	0·60400	$\bar{1}$·781 04
„	$Mg_2As_2O_7$ „ As_2	0·48274	$\bar{1}$·683 71
„	„ „ As_2O_3	0·63730	$\bar{1}$·804 34
„	„ „ As_2O_5	0·74034	$\bar{1}$·869 43
„	As_2O_3 „ As_2	0·75748	$\bar{1}$·879 37
„	As_2S_3 „ As_2	0·60911	$\bar{1}$·784 70
„	„ „ As_2O_3	0·80413	$\bar{1}$·905 33
„	„ „ As_2O_5	0·93414	$\bar{1}$·970 41

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	BARIUM (Ba = 137·37)				
Ba	$BaSO_4$	into	Ba	0·58846	$\bar{1}$·769 72
”	”	”	BaO	0·65700	$\bar{1}$·817 57
”	”	”	$BaCO_3$	0·84548	$\bar{1}$·927 11
”	”	”	$BaCl_2$	0·89226	$\bar{1}$·950 49
”	”	”	$BaCl_2, 2H_2O$	1·04662	0·019 79
”	”	”	S	0·13738	$\bar{1}$·137 92
”	”	”	SO_3	0·34300	$\bar{1}$·535 29
”	”	”	SO_4	0·41154	$\bar{1}$·614 41
”	”	”	H_2SO_4	0·42018	$\bar{1}$·623 43
”	”	”	$CaSO_4$	0·58319	$\bar{1}$·765 81
”	”	”	$CaSO_4, 2H_2O$	0·73754	$\bar{1}$·867 79
”	”	”	$FeSO_4, 7H_2O$	1·19100	0·075 90
”	”	”	$PbSO_4$	1·29871	0·113 51
”	”	”	$MgSO_4$	0·51572	$\bar{1}$·712 42
”	”	”	K_2SO_4	0·74653	$\bar{1}$·873 05
”	”	”	Na_2SO_4	0·60859	$\bar{1}$·784 33
”	”	”	$Na_2SO_4, 10H_2O$	1·38035	0·139 99
”	”	”	$(NH_4)_2SO_4$	0·56612	$\bar{1}$·752 91
”	$2BaSO_4$	”	FeS_2	0·25698	$\bar{1}$·409 90
”	$4BaSO_4$	”	$Al_2(NH_4)_2(SO_4)_4, 24H_2O$	0·97129	$\bar{1}$·987 35
”	$BaCO_3$	”	Ba	0·69600	$\bar{1}$·842 61
”	”	”	BaO	0·77707	$\bar{1}$·890 46
”	”	”	CO_2	0·30400	$\bar{1}$·482 87
	BISMUTH (Bi = 208)				
Bi	Bi_2O_3	into	Bi_2	0·89655	$\bar{1}$·952 58
”	Bi_2S_3	”	Bi_2	0·81217	$\bar{1}$·909 65

Factors and their Logarithms required in Gravimetric Analysis—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	BORON (B=11)				
B	B_2O_3	into	B_2	0·31428	$\bar{1}$·497 32
„	B_2O_3	„	$2H_3BO_3$	1·77212	0·248 49
„	$2H_3BO_3$	„	B_2O_3	0·56430	$\bar{1}$·751 51
	CADMIUM (Cd = 112·4)				
Cd	CdO	into	Cd	0·87539	$\bar{1}$·942 20
„	CdS	„	Cd	0·77801	$\bar{1}$·890 99
„	„	„	CdO	0·88877	$\bar{1}$·948 79
	CALCIUM (Ca = 40·07)				
Ca	CaO	into	Ca	0·71464	$\bar{1}$·854 09
„	„	„	$CaCO_3$	1·78473	0·251 57
„	„	„	$CaSO_4$	2·42804	0·385 26
„	„	„	$CaSO_4, 2H_2O$	3·07066	0·487 23
„	„	„	$CaCl_2$	1·97949	0·296 55
„	„	„	CaH_2O_2	1·32131	0·121 01
„	3CaO	„	$Ca_3P_2O_8$	1·84466	0·265 92
„	$CaCl_2$	„	CaO	0·50518	$\bar{1}$·703 45
„	„	„	Cl_2	0·63897	$\bar{1}$·805 48
„	$CaCO_3$	„	Ca	0·40042	$\bar{1}$·602 52
„	„	„	CaO	0·56031	$\bar{1}$·748 43
„	„	„	CO_2	0·43969	$\bar{1}$·643 15
„	„	„	CO_3	0·59958	$\bar{1}$·777 85
„	„	„	$CaSO_4$	1·36045	0·133 68
„	„	„	$CaSO_4, 2H_2O$	1·72052	0·235 66
„	$CaSO_4$	„	Ca	0·29433	$\bar{1}$·468 83
„	„	„	CaO	0·41186	$\bar{1}$·614 74
„	„	„	$CaCO_3$	0·73505	$\bar{1}$·866 32

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
Ca	CALCIUM (Ca = 40·07) —*continued.*				
,,	$CaSO_4$	into	$CaSO_4, 2H_2O$	1·26467	0·101 98
,,	,,	,,	SO_3	0·58814	$\bar{1}$·769 48
,,	$Ca_3P_2O_8$	,,	CaP_2O_6	0·63860	$\bar{1}$·805 23
,,	,,	,,	$CaH_4P_2O_8$	0·75472	$\bar{1}$·877 79
,,	,,	,,	P_2O_5	0·45789	$\bar{1}$·660 77
,,	,,	,,	P_2	0·20007	$\bar{1}$·301 18
,,	$CaH_4P_2O_8$	,,	$Ca_3P_2O_8$	1·32500	0·122 21
	CARBON (C = 12)				
C	CO_2	into	C	0·27273	$\bar{1}$·435 73
,,	,,	,,	$CaCO_3$	2·27432	0·356 85
,,	,,	,,	Na_2CO_3	2·40910	0·381 85
,,	,,	,,	$NaHCO_3$	1·90927	0·280 87
,,	,,	,,	$PbCO_3$	6·07045	0·783 22
,,	$2CO_2$	,,	MnO_2	0·98784	$\bar{1}$·994 69
,,	C_2H_6O	,,	$C_2H_4O_2$	1·30368	0·115 17
	CHLORINE (Cl = 35·46)				
Cl	Cl	into	HCl	1·02843	0·012 17
,,	,,	,,	NaCl	1·64862	0·217 12
,,	,,	,,	KCl	2·10265	0·322 77
,,	Cl_2	,,	$MgCl_2$	1·34292	0·128 05
,,	,,	,,	$CaCl_2$	1·56500	0·194 52
,,	,,	,,	O	0·22560	$\bar{1}$·353 35
	CHROMIUM (Cr = 52)				
Cr	Cr_2O_3	into	Cr_2	0·68421	$\bar{1}$·835 19
,,	,,	,,	$K_2Cr_2O_7$	1·93553	0·286 80
	COBALT (Co = 58·97)				
Co	CoO	into	Co	0·78658	$\bar{1}$·895 74

Factors and their Logarithms required in Gravimetric Analysis—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	Copper (Cu = 63·57)				
Cu	Cu	into	CuO	1·25170	0·097 50
,,	CuO	,,	Cu	0·79892	$\bar{1}$·902 50
,,	2CuO	,,	Cu_2O	0·89946	$\bar{1}$·953 98
,,	Cu_2O	,,	2CuO	1·11178	0·046 02
,,	CuSCN	,,	Cu	0·52256	$\bar{1}$·718 14
	Fluorine (F = 19)				
F	CaF_2	into	F_2	0·48674	$\bar{1}$·687 30
,,	,,	,,	2HF	0·51256	$\bar{1}$·709 75
	Hydrogen (H = 1·008)				
H	HCl	into	Cl	0·97236	$\bar{1}$·987 83
,,	HNO_3	,,	N	0·22232	$\bar{1}$·346 97
,,	,,	,,	$NaNO_3$	1·34898	0·130 01
,,	$2HNO_3$	,,	N_2O_5	0·85705	$\bar{1}$·933 01
,,	H_2SO_4	,,	$(NH_4)_2SO_4$	1·34743	0·129 47
,,	,,	,,	2HCl	0·74359	$\bar{1}$·871 33
,,	,,	,,	SO_3	0·81633	$\bar{1}$·911 86
,,	$2C_2H_4O_2$	,,	$Ca(C_2H_3O_2)_2$	1·31695	0·119 57
	Iron (Fe = 55·84)				
Fe	Fe	into	FeO	1·28653	0·109 42
,,	,,	,,	$FeCO_3$	2·07450	0·316 91
,,	,,	,,	FeS_2	2·14864	0·332 16
,,	,,	,,	$FeSO_4,7H_2O$	4·97890	0·697 13
,,	Fe_2	,,	Fe_2O_3	1·42980	0·155 28
,,	,,	,,	$Fe_2O_3 . H_2O$	1·59112	0·201 70
,,	,,	,,	$Fe_2O_3 . 3H_2O$	1·91375	0·281 89

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	IRON (Fe = 55·84)—*continued.*				
Fe	Fe_2	into	$Fe_2(PO_4)_2$	2·70200	0·431 69
,,	,,	,,	MnO_2	0·77838	$\bar{1}$·891 19
,,	Fe_2O_3	,,	Fe_2	0·69940	$\bar{1}$·844 72
,,	,,	,,	$Fe_2(PO_4)_2$	1·88978	0·276 41
,,	$3Fe_2O_3$	,,	$2Fe_3O_4$	0·96660	$\bar{1}$·985 25
,,	FeS	,,	Fe	0·63520	$\bar{1}$·802 91
,,	2FeS	,,	Fe_2O_3	0·90820	$\bar{1}$·958 18
,,	FeS_2	,,	S_2	0·53459	$\bar{1}$·728 02
,,	$2\{Fe(NH_4)_2(SO_4)_2,6H_2O\}$	into	MnO_2	0·11083	$\bar{1}$·044 68
	LEAD (Pb = 207·1)				
Pb	Pb	into	PbO	1·07726	0·032 32
,,	PbS	,,	Pb	0·86591	$\bar{1}$·937 47
,,	,,	,,	PbO	0·93281	$\bar{1}$·969 79
,,	3PbO	,,	$2PbCO_3, Pb(OH)_2$	1·15840	0·063 86
,,	PbO_2	,,	Pb	0·86617	$\bar{1}$·937 60
,,	$PbSO_4$	,,	Pb	0·68312	$\bar{1}$·834 49
,,	,,	,,	PbO	0·73589	$\bar{1}$·866 81
,,	,,	,,	PbS	0·78890	$\bar{1}$·897 02
,,	$PbCrO_4$	,,	Pb	0·64098	$\bar{1}$·806 84
,,	,,	,,	PbO	0·69050	$\bar{1}$·839 16
,,	,,	,,	$PbSO_4$	0·93832	$\bar{1}$·972 35
,,	$2PbCrO_4$	,,	Cr_2O_3	0·23522	$\bar{1}$·371 48
,,	,,	,,	$K_2Cr_2O_7$	0·45528	$\bar{1}$·658 28
,,	$3PbCrO_4$	,,	$2PbCO_3, Pb(OH)_2$	0·79987	$\bar{1}$·903 02

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	MAGNESIUM (Mg = 24·32)				
Mg	$MgCl_2$	into	MgO	0·42335	$\bar{1}$·626 70
,,	,,	,,	Cl_2	0·74464	$\bar{1}$·871 95
,,	MgO	,,	$MgCO_3$	2·09127	0·320 41
,,	,,	,,	$MgCl_2$	2·36210	0·373 30
,,	,,	,,	$MgSO_4$	2·98586	0·475 07
,,	,,	,,	$MgSO_4, 7H_2O$	6·11364	0·786 30
,,	,,	,,	$Mg(NO_3)_2$	3·67907	0·565 74
,,	$Mg_2P_2O_7$	,,	Mg_2	0·21839	$\bar{1}$·339 23
,,	,,	,,	$2MgO$	*0·36207	$\bar{1}$·558 79
,,	,,	,,	$2MgCO_3$	0·75718	$\bar{1}$·879 20
,,	,,	,,	$2MgCl_2$	0·85524	$\bar{1}$·932 09
,,	,,	,,	$2MgSO_4$	1·08109	0·033 86
,,	,,	,,	$2(MgSO_4, 7H_2O)$	2·21356	0·345 09
,,	,,	,,	P_2	0·27874	$\bar{1}$·445 19
,,	,,	,,	P_2O_5	0·63793	$\bar{1}$·804 77
,,	,,	,,	$2H_3PO_4$	0·88060	$\bar{1}$·944 78
,,	,,	,,	$CaH_4(PO_4)_2$	1·05146	0·021 79
,,	,,	,,	$Ca(PO_3)_2$	0·88968	$\bar{1}$·949 23
,,	,,	,,	$Ca_3(PO_4)_2$	1·39318	0·144 01
,,	$MgSO_4$	,,	Mg	0·20201	$\bar{1}$·305 37
,,	,,	,,	MgO	0·33491	$\bar{1}$·524 93
	MANGANESE (Mn = 54·93)				
Mn	Mn	into	MnO	1·29128	0·111 02
,,	MnO	,,	Mn	0·77442	$\bar{1}$·888 98
,,	MnO_2	,,	Mn	0·63189	$\bar{1}$·800 64

* Or use the Phosphate Table, pp. 121–128, subtracting from the $Mg_2P_2O_7$ found the P_2O_5 in it.

Factors and their Logarithms required in Gravimetric Analysis—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	Manganese ($Mn = 54·93$)—*contd.*				
Mn	Mn_3O_4	into	3Mn	0·72027	$\bar{1}$·857 49
,,	,,	,,	3MnO	0·93007	$\bar{1}$·968 51
,,	MnS	,,	Mn	0·63138	$\bar{1}$·800 29
,,	,,	,,	MnO	0·81529	$\bar{1}$·911 31
,,	$MnSO_4$	,,	Mn	0·36377	$\bar{1}$·560 83
,,	,,	,,	MnO	0·46974	$\bar{1}$·671 85
	Mercury ($Hg = 200·6$)				
Hg	HgS	into	Hg	0·86217	$\bar{1}$·935 59
,,	,,	,,	HgO	0·93093	$\bar{1}$·968 92
,,	Hg_2Cl_2	,,	2Hg	0·84978	$\bar{1}$·929 31
,,	,,	,,	Hg_2O	0·88367	$\bar{1}$·946 29
	Molybdenum				
Mo	Ammonium phospho-molybdate (dried at 100° C.)	into	P	0·0163	$\bar{2}$·212 19
,,		,,	,, P_2O_5	0·0373	$\bar{2}$·571 77
,,		,,	into $Ca_3(PO_4)_2$	0·08147	$\bar{2}$·911 00
	Nickel ($Ni = 58·68$)				
Ni	NiO	into	Ni	0·78575	$\bar{1}$·895 29
	Nitrogen (14·01) and Ammonium (18·042)				
N	N	into	NH_3	1·21585	0·084 88
,,	,,	,,	HNO_3	4·49807	0·653 03
,,	,,	,,	$NaNO_3$	6·06780	0·783 03
,,	,,	,,	KNO_3	7·21700	0·858 36
,,	,,	,,	Albuminoids	6·25	0·795 88
,,	,,	,,	Caffeine	3·46395	0·539 57

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	NITROGEN (14·01) AND AMMONIUM (18·042)—*continued.*				
N	N_2	into	$(NH_4)_2SO_4$	4·71642	0·673 61
,,	,,	,,	N_2O_5	3·85510	0·586 04
,,	N_2O_5	,,	N_2	0·25940	$\bar{1}$·413 96
,,	,,	,,	$2NaNO_3$	1·57397	0·197 00
,,	,,	,,	$2KNO_3$	1·87206	0·272 32
,,	,,	,,	$Ca(NO_3)_2$	1·51907	0·181 58
,,	,,	,,	$Mg(NO_3)_2$	1·37326	0·137 75
,,	NH_3	,,	N	0·82247	$\bar{1}$·915 12
,,	,,	,,	NH_4Cl	3·14090	0·497 05
,,	$2NH_3$	,,	$(NH_4)_2SO_4$	3·87912	0·588 73
,,	NH_4Cl	,,	N	0·26186	$\bar{1}$·418 07
,,	,,	,,	NH_3	0·31838	$\bar{1}$·502 95
,,	$(NH_4)_2SO_4$	,,	N_2	0·21202	$\bar{1}$·326 39
,,	,,	,,	$2NH_3$	0·25779	$\bar{1}$·411 27
,,	,,	,,	H_2SO_4	0·74221	$\bar{1}$·870 53
	PHOSPHORUS (P = 31·04)				
P	P_2	into	P_2O_5	2·28866	0·359 58
,,	P_2O_5	,,	P_2	0·43694	$\bar{1}$·640 42
,,	,,	,,	$Ca_3(PO_4)_2$	2·18391	0·339 23
,,	,,	,,	$CaH_4(PO_4)_2$	1·64824	0·217 02
	PLATINUM (Pt = 195·2)				
Pt	$(NH_4)_2PtCl_6$	into	N_2	0·06310	$\bar{2}$·800 04
,,	,,	,,	$2NH_3$	0·07672	$\bar{2}$·884 92
,,	,,	,,	$2NH_4Cl$	0·24098	$\bar{1}$·381 97
,,	,,	,,	$(NH_4)_2SO_4$	0·29761	$\bar{1}$·473 65

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	PLATINUM (Pt = 195·2)—*contd.*				
Pt	K_2PtCl_6*	into	K_2	0·16085	$\bar{1}$·206 43
,,	,,	,,	2KCl	0·30673	$\bar{1}$·486 76
,,	,,	,,	K_2O	0·19376	$\bar{1}$·287 27
,,	,,	,,	K_2SO_4	0·35846	$\bar{1}$·554 44
,,	Pt	,,	$2NH_4Cl$	0·54818	$\bar{1}$·738 92
,,	,,	,,	$(NH_4)_2SO_4$	0·67702	$\bar{1}$·830 60
	POTASSIUM (K = 39·1)				
K	K	into	KCl	1·90690	0·280 33
,,	K_2	,,	K_2O	1·20460	0·080 84
,,	KCl	,,	Cl	0·47559	$\bar{1}$·677 23
,,	,,	,,	$KHC_4H_4O_6$	2·52320	0·401 95
,,	2KCl	,,	K_2O	0·63171	$\bar{1}$·800 52
,,	,,	,,	K_2SO_4	1·16866	0·067 69
,,	$KClO_4$	,,	KCl	0·5381†	$\bar{1}$·730 87
,,	$2KClO_4$	,,	K_2O	0·3400†	$\bar{1}$·531 44
,,	,,	,,	K_2SO_4	0·62887†	$\bar{1}$·798 56

* International methods of determining potash were adopted at the International Congress of Applied Chemistry held at Berlin, 1903 (see *Chemical News*, No. 2619,‡ Feb. 4, 1910). The platinochloride pp. is to be dried at 120–130° C., weighed warm, and the following factors (which are based on Berzelius's atomic weight Pt = 197·2) used :—

$K_2PtCl_6 \times 0{\cdot}3056 = KCl$ (log. $\bar{1}$·48515)
,, $\times 0{\cdot}19305 = K_2O$ (log. $\bar{1}$·28567)
,, $\times 0{\cdot}35714 = K_2SO_4$ (log. $\bar{1}$·55284)

† These are the factors used in connection with the International perchloric acid method for determining potash (see note above).

‡ Also reprinted in pamphlet form.

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	POTASSIUM (K = 39·1)—*contd.*				
K	K_2O	into	2KCl	1·58301	0·199 49
,,	,,	,,	K_2SO_4	1·85000	0·267 17
,,	,,	,,	$2KNO_3$	2·14671	0·331 77
,,	,,	,,	K_2CO_3	1·46709	0·166 46
,,	,,	into	$2\{KNaC_4H_4O_6, 4H_2O\}$	5·99138	0·777 53
,,	,,	into	$2KHC_4H_4O_6$	3·99427	0·601 44
,,	,,	,,	2KOH	1·19125	0·076 00
,,	2KOH	,,	K_2O	0·83945	$\bar{1}$·924 00
,,	K_2CO_3	,,	K_2O	0·68162	$\bar{1}$·833 54
,,	K_2SO_4	,,	K_2O	0·54054	$\bar{1}$·732 83
,,	,,	,,	2KCl	0·85568	$\bar{1}$·932 31
,,	KNO_3	,,	N	0·13856	$\bar{1}$·141 64
	SILICON (Si = 28·3)				
Si	SiO_2	into	Si	0·46932	$\bar{1}$·671 47
	SILVER (Ag = 107·88)				
Ag	AgBr	into	Br	0·42556	$\bar{1}$·628 96
,,	AgCl	,,	Ag	0·75262	$\bar{1}$·876 57
,,	,,	,,	Cl	0·24738	$\bar{1}$·393 37
,,	,,	,,	HCl	0·25442	$\bar{1}$·405 54
,,	,,	,,	$AgNO_3$	1·18522	0·073 80
,,	AgI	,,	I	0·54055	$\bar{1}$·732 83
	SODIUM (Na = 23)				
Na	Na	into	NaCl	2·54174	0·405 13
,,	Na_2	,,	Na_2O	1·34783	0·129 63
,,	Na_2O	,,	2NaCl	1·88580	0·275 50

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	SODIUM (Na = 23)—*continued.*				
Na	Na_2O	into	Na_2SO_4	2·29145	0·360 11
”	”	”	Na_2CO_3	1·70968	0·232 91
”	”	”	$2NaNO_3$	2·74226	0·438 11
”	”	”	2NaOH	1·29058	0·110 79
”	$Na_2B_4O_7$	”	$Na_2B_4O_7$, $10H_2O$	1·89109	0·276 71
”	NaCl	”	Cl	0·60657	$\bar{1}$·782 88
”	”	”	$NaHCO_3$	1·43702	0·157 46
”	2NaCl	”	Na_2O	0·53028	$\bar{1}$·724 50
”	”	”	Na_2CO_3	0·90660	$\bar{1}$·957 42
”	Na_2CO_3	”	Na_2O	0·58491	$\bar{1}$·767 09
”	$NaNO_3$	”	N	0·16480	$\bar{1}$·216 97
”	2NaOH	”	Na_2O	0·77484	$\bar{1}$·889 21
”	Na_2CO_3	”	Na_2CO_3, $10H_2O$	2·69811	0·431 06
”	Na_2SO_4	”	Na_2	0·32378	$\bar{1}$·510 26
”	”	”	Na_2O	0·43640	1·639 89
	STRONTIUM (Sr = 87·63)				
Sr	$SrCO_3$	into	Sr	0·59358	$\bar{1}$·773 48
”	$SrSO_4$	”	Sr	0·47703	$\bar{1}$·678 54
	SULPHUR (S = 32·07)				
S	SO_3	into	S	0·40052	$\bar{1}$·602 63
”	”	”	$CaSO_4$	1·70026	0·230 52
”	”	”	$CaSO_4$, $2H_2O$	2·15027	0·332 49
”	”	”	H_2SO_4	1·22500	0·088 14
”	”	”	$(NH_4)_2SO_4$	1·65048	0·217 61

FACTORS AND THEIR LOGARITHMS REQUIRED IN GRAVIMETRIC ANALYSIS—*continued.*

Element.	To convert			Factor.	Logarithm (to be *added*).
	SULPHUR ($S=32{\cdot}07$)—*continued.*				
S	SO_3	into	K_2SO_4	2·17647	0·337 75
„	„	„	Na_2SO_4	1·77432	0·249 03
„	„	„	$MgSO_4$	1·50356	0·177 12
	TIN ($Sn=119$)				
Sn	Sn	into	SnO_2	1·26891	0·103 43
„	SnO_2	„	Sn	0·78808	$\bar{1}$·896 57
	ZINC ($Zn=65{\cdot}37$)				
Zn	Zn	into	ZnO	1·24476	0·095 09
„	„	„	ZnS	1·49059	0·173 36
„	„	„	$ZnCl_2$	2·08490	0·319 09
„	ZnO	„	Zn	0·80337	$\bar{1}$·904 91
„	ZnS	„	Zn	0·67087	$\bar{1}$·826 64

Example.—1·327 grams of a substance gave 0·8470 gram $BaSO_4$: to find the percentages of SO_3 and S present respectively.

Since 1·327 grams give 0·847 gram $BaSO_4$ 100 grams will give $\frac{\cdot 847\times 100}{1\cdot 327}=\frac{84\cdot 70}{1\cdot 327}$.

Taking logs. Log. 84·70 = 1·92788
„ 1·327 = 0·12287

(subtracting) 1·80501
Add log. ($BaSO_4$ into SO_3) $\bar{1}$·53529

1·34030 = 21·89 per cent. SO_3.
Add log. (SO_3 into S) $\bar{1}$·60263

0·94293 = 8·77 per cent. S.

Rule.—First find the weight of the pp. that 100 parts of substance would give, then add the log. of the factor to get percentage of substance sought.

Element.	To convert	Factor.	Logarithm (to be *added*).

Volumetric Factors.

Definition.—A Normal Solution of a reagent is one that contains in a litre that proportion of its molecular weight in grams which corresponds to one gram of available hydrogen or its equivalent.

Up till recent years the atomic weights of elements were referred to hydrogen as unity. Now, however, oxygen = 16 is the standard of reference, and the present atomic weight of hydrogen is taken as 1·008. Hence, "one gram" in the above definition must actually be taken as 1·008 gram.

Thus, a normal solution of hydrochloric acid contains ·36·468 grams HCl per litre; and normal sulphuric acid $\frac{98 \cdot 086}{2} = 49 \cdot 043$ grams H_2SO_4 per litre. Potassium permanganate, $K_2Mn_2O_8$, in acid solution, yields 5 atoms of oxygen, equivalent to 10 atoms of hydrogen; hence a normal solution of permanganate contains $\frac{316 \cdot 06}{10} = 31 \cdot 606$ grams per litre. Normal alkali solutions are such that a given volume requires for neutralization an equal volume of a normal acid solution.

	grams.	Logarithms.
Normal H_2SO_4	1 c.c. = 0·049043 H_2SO_4 . . .	$\bar{2}$·690 58
	,, = 0·048035 SO_4 . . .	$\bar{2}$·681 56
	,, = 0·040035 SO_3 . . .	2·602 44
Normal HCl	1 c.c. = 0·036468 HCl . . .	$\bar{2}$·561 91
	,, = 0·03546 Cl . . .	$\bar{2}$·549 74
Normal HNO_3	1 c.c. = 0·063018 HNO_3 . .	$\bar{2}$·799 46
	,, = 0·06201 NO_3 . . .	$\bar{2}$·792 46
	,, = 0·05401 N_2O_5 . . .	$\bar{2}$·732 47
Normal $H_2C_2O_4$	1 c.c. = 0·063024 $H_2C_2O_4$, $2H_2O$.	$\bar{2}$·799 51
	,, = 0·045008 $H_2C_2O_4$ . .	$\bar{2}$·653 29
Normal acid	1 c.c. = 0·017034 NH_3 . . .	$\bar{2}$·231 32
	,, = 0·03505 NH_4OH . .	$\bar{2}$·544 69
	,, = 0·101 $Na_2B_4O_7$ . .	$\bar{1}$·004 32
	,, = 0·19108 $Na_2B_4O_7$, $10H_2O$	$\bar{1}$·281 22

Volumetric Factors—*continued.*

		grams.		Logarithms.
Normal acid (*continued*).	1 c.c.	= 0·028035	CaO	$\bar{2}$·447 70
	„	= 0·037043	$Ca(OH)_2$	$\bar{2}$·568 71
	„	= 0·050035	$CaCO_3$	$\bar{2}$·699 27
	„	= 0·085693	$Ba(OH)_2$	$\bar{2}$·932 95
	„	= 0·157757	$Ba(OH)_2$, $8H_2O$	$\bar{1}$·197 99
	„	= 0·098685	$BaCO_3$	$\bar{2}$·994 25
	„	= 0·02016	MgO	$\bar{2}$·304 49
	„	= 0·04216	$MgCO_3$	$\bar{2}$·624 90
	„	= 0·056108	KOH	$\bar{2}$·749 02
	„	= 0·0691	K_2CO_3	$\bar{2}$·839 48
	„	= 0·18814	$KHC_4H_4O_6$	$\bar{1}$·274 48
	„	= 0·108119	$K_3C_6H_5O_7$, H_2O	$\bar{1}$·033 90
	„	= 0·098124	$KC_2H_3O_2$	$\bar{2}$·991 78
	„	= 0·141098	$KNaC_4H_4O_6$, $4H_2O$	$\bar{1}$·149 52
	„	= 0·040008	NaOH	$\bar{2}$·602 15
	„	= 0·053	Na_2CO_3	$\bar{2}$·724 28
	„	= 0·14308	Na_2CO_3, $10H_2O$	$\bar{1}$·155 58
	„	= 0·084008	$NaHCO_3$	$\bar{2}$·924 36
Normal KOH	1 c.c.	= 0·056108	KOH	$\bar{2}$·749 02
	„	= 0·0471	K_2O	$\bar{2}$·673 02
Normal NaOH	1 c.c.	= 0·040008	NaOH	$\bar{2}$·602 15
	„	= 0·031	Na_2O	$\bar{2}$·491 36
Normal Na_2CO_3	1 c.c.	= 0·053	Na_2CO_3	$\bar{2}$·724 28
	„	= 0·030	CO_3	$\bar{2}$·477 12
	„	= 0·022	CO_2	$\bar{2}$·342 42
Normal alkali	1 c.c.	= 0·060032	$HC_2H_3O_2$	$\bar{2}$·778 38
	„	= 0·035	B_2O_3	$\bar{2}$·544 07
	„	= 0·062024	H_3BO_3	$\bar{2}$·792 56
	„	= 0·0505	$Na_2B_4O_7$	$\bar{2}$·703 29
	„	= 0·09554	$Na_2B_4O_7$, $10H_2O$	$\bar{2}$·980 19

VOLUMETRIC FACTORS—*continued.*

		grams.	Logarithms.
Normal alkali (*continued*).	1 c.c.	= 0·070027 $H_3C_6H_5O_7$, H_2O	$\bar{2}$·845 27
	,,	= 0·122048 benzoic acid	$\bar{1}$·086 53
	,,	= 0·088064 butyric ,,	$\bar{2}$·944 80
	,,	= 0·410432 cerotic ,,	$\bar{1}$·613 24
	,,	= 0·090048 lactic ,,	$\bar{2}$·954 47
	,,	= 0·067024 malic ,,	$\bar{2}$·826 23
	,,	= 0·282272 oleic ,,	$\bar{1}$·450 67
	,,	= 0·256256 palmitic ,,	$\bar{1}$·408 67
	,,	= 0·284288 stearic ,,	$\bar{1}$·453 76
	,,	= 0·075024 tartaric ,,	$\bar{2}$·875 20
	,,	= 0·18814 $KHC_4H_4O_6$	$\bar{1}$·274 48
$\frac{N}{10}$ $AgNO_3$	1 c.c.	= 0·010788 Ag	$\bar{2}$·032 94
	,,	= 0·016989 $AgNO_3$	$\bar{2}$·230 17
	,,	= 0·003546 Cl	$\bar{3}$·549 74
	,,	= 0·005846 NaCl	$\bar{3}$·766 86
	,,	= 0·0053502 NH_4Cl	$\bar{3}$·728 37
	,,	= 0·011902 KBr	$\bar{2}$·075 62
	,,	= 0·007456 KCl	$\bar{3}$·872 51
	,,	= 0·016602 KI	$\bar{2}$·220 16
	,,	= 0·010292 NaBr	$\bar{2}$·012 50
	,,	= 0·006199 Na_2HAsO_4	$\bar{3}$·792 32
$\frac{N}{10}$ Iodine	1 c.c	= 0·0032035 SO_2	$\bar{3}$·505 62
	,,	= 0·0041043 H_2SO_3	$\bar{3}$·613 24
	,,	= 0·0126091 Na_2SO_3, $7H_2O$	$\bar{2}$·100 68
	,,	= 0·0097151 K_2SO_3, $2H_2O$	$\bar{3}$·987 45
	,,	= 0·024822 $Na_2S_2O_3$, $5H_2O$	$\bar{2}$·394 84
	,,	= 0·004948 As_4O_6	$\bar{3}$·694 43
$\frac{N}{10}$ Dichromate	1 c.c.	= 0·005584 Fe	$\bar{3}$·746 95
	,,	= 0·007184 FeO	$\bar{3}$·856 37
	,,	= 0·011584 $FeCO_3$	$\bar{2}$·063 86
	,,	= 0·015191 $FeSO_4$	$\bar{2}$·181 59
	,,	= 0·0278022 $FeSO_4$, $7H_2O$	$\bar{2}$·444 08

VOLUMETRIC FACTORS—*continued.*

		grams.	Logarithms.
$\frac{N}{10}$ Thiosulphate	1 c.c.	$= 0.024822\ Na_2S_2O_3, 5H_2O$.	$\bar{2}.394\ 84$
	,,	$= 0.012692$ I . . .	$\bar{2}.103\ 53$
	,,	$= 0.003546$ Cl . . .	$\bar{3}.549\ 74$
	,,	$= 0.007992$ Br . . .	$\bar{3}.902\ 66$

CALCIUM (Ca = 40·07)

1 c.c. $\frac{N}{10}$ permanganate = 0·0028035 gram CaO .	$\bar{3}.447\ 70$
,, ,, = 0·0050035 gram $CaCO_3$.	$\bar{3}.699\ 27$
,, ,, = 0·0086086 gram $CaSO_4$, $2OH_2$	$\bar{3}.934\ 93$
,, normal oxalic acid = 0·028035 gram CaO .	$\bar{2}.447\ 70$
Cryst. oxalic acid × 0·444 = CaO	$\bar{1}.647\ 38$
Ferrous ammonium sulphate × 0·07143 = CaO .	$\bar{2}.853\ 88$

CHLORINE (Cl = 35·46)

1 c.c. $\frac{N}{10}$ silver solution = 0·003546 gram Cl . .	$\bar{3}.549\ 74$
,, ,, = 0·005846 gram NaCl .	$\bar{3}.766\ 86$
1 c.c. $\frac{N}{10}$ arsenious or thiosulphate solution = 0·003546 gram Cl	$\bar{3}.549\ 74$

CHROMIUM (Cr = 52)

Metallic iron × 0·3104 = Cr	$\bar{1}.491\ 94$
,, × 0·5968 = CrO_3	$\bar{1}.775\ 86$
,, × 0·8780 = $K_2Cr_2O_7$	$\bar{1}.943\ 47$
,, × 1·928 = $PbCrO_4$	$0.285\ 19$
Ferrous ammonium sulphate × 0·0443 = Cr . .	$\bar{2}.646\ 40$
,, × 0·0853 = CrO_3 .	$\bar{2}.930\ 95$
,, × 0·1253 = $K_2Cr_2O_7$.	$\bar{1}.097\ 95$
,, × 0·2754 = $PbCrO_4$.	$\bar{1}.439\ 96$
1 c.c. $\frac{N}{10}$ solution = 0·003333 gram CrO_3 . .	$\bar{3}.522\ 84$
,, ,, = 0·004903 gram $K_2Cr_2O_7$ . .	$\bar{3}.690\ 45$

VOLUMETRIC FACTORS—*continued.*

	Logarithms.
COPPER (Cu = 63·57)	
1 c.c. $\frac{N}{10}$ solution = 0·006357 gram Cu . . .	$\bar{3}$·803 25
Iron × 1·138 = copper	0·056 14
Ferrous ammonium sulphate × 0·1622 = copper .	$\bar{1}$·210 05
CYANOGEN (CN = 26·01)	
1 c.c. $\frac{N}{10}$ silver solution = 0·005202 gram CN .	$\bar{3}$·716 17
" " = 0·005404 gram HCN .	$\bar{3}$·732 72
" " = 0·013022 gram KCN .	$\bar{2}$·114 68
" $\frac{N}{10}$ iodine = 0·003255 gram KCN .	$\bar{3}$·512 55
POTASSIUM FERROCYANIDE (K_4FeCy_6, $3OH_2$ = 422·348)	
Metallic iron × 7·563 = cryst. potassium ferrocyanide	0·878 69
Ferrous ammonium sulphate × 1·080 = cryst. potassium ferrocyanide	0·033 42
POTASSIUM FERRICYANIDE ($K_6Fe_2Cy_{12}$ = 658·4)	
Metallic iron × 5·895 = potassium ferricyanide .	0·770 48
Ferrous ammonium sulphate × 1·684 = potassium ferricyanide	0·226 34
$\frac{N}{10}$ thiosulphate × 0·03292 = potassium ferricyanide	$\bar{2}$·517 46
GOLD (Au = 197·2)	
1 c.c. normal oxalic acid = 0·0657 gram gold .	$\bar{2}$·817 57
IODINE (I = 126·92)	
1 c.c. $\frac{N}{10}$ thiosulphate = 0·012692 gram iodine .	$\bar{2}$·103 53
IRON (Fe = 55·84)	
1 c.c. $\frac{N}{10}$ permanganate, dichromate, or thiosulphate = 0·005584 Fe .	$\bar{3}$·746 95
" " = 0·007184 FeO .	$\bar{3}$·856 37
" " = 0·007984 Fe_2O_3	$\bar{3}$·902 22

VOLUMETRIC FACTORS—*continued.*

	Logarithms.
LEAD ($Pb = 207 \cdot 1$)	
1 c.c. $\frac{N}{10}$ permanganate $= 0 \cdot 010355$ gram lead .	$\bar{2} \cdot 015\ 15$
1 c.c. normal oxalic acid $= 0 \cdot 10355$ gram lead .	$\bar{1} \cdot 015\ 15$
Metallic iron $\times 1 \cdot 854 =$ lead . .	$0 \cdot 268\ 20$
Ferrous ammonium sulphate $\times 0 \cdot 265 =$ lead .	$\bar{1} \cdot 423\ 25$
MANGANESE ($Mn = 54 \cdot 93$)	
$MnO = 70 \cdot 93$. $MnO_2 = 86 \cdot 93$.	
Metallic iron $\times 0 \cdot 4918 = Mn$	$\bar{1} \cdot 691\ 79$
,, $\times 0 \cdot 6350 = MnO$	$\bar{1} \cdot 802\ 77$
,, $\times 0 \cdot 7783 = MnO_2$	$\bar{1} \cdot 891\ 15$
Ferrous ammonium sulphate $\times 0 \cdot 0907 = MnO$.	$\bar{2} \cdot 957\ 61$
,, $\times 0 \cdot 1112 = MnO_2$.	$\bar{1} \cdot 046\ 10$
Cryst. oxalic acid $\times 0 \cdot 6896 = MnO_2$.	$\bar{1} \cdot 838\ 60$
1 c.c. $\frac{N}{10}$ solution $= 0 \cdot 003547$ gram MnO . .	$\bar{3} \cdot 549\ 86$
,, ,, $= 0 \cdot 004347$ gram MnO_2 . .	$\bar{3} \cdot 638\ 19$
MERCURY ($Hg = 200 \cdot 6$)	
Ferrous ammonium sulphate $\times 0 \cdot 5115 = Hg$ . .	$\bar{1} \cdot 708\ 86$
,, $\times 0 \cdot 6924 = HgCl_2$.	$\bar{1} \cdot 840\ 33$
1 c.c. $\frac{N}{10}$ solution $= 0 \cdot 02006$ gram Hg . . .	$\bar{2} \cdot 302\ 33$
,, ,, $= 0 \cdot 02086$ gram Hg_2O . .	$\bar{2} \cdot 319\ 31$
,, ,, $= 0 \cdot 027152$ gram $HgCl_2$ . .	$\bar{2} \cdot 433\ 80$
NITROGEN AS NITRATES AND NITRITES	
$N_2O_5 = 108 \cdot 02$ $N_2O_3 = 76 \cdot 02$	
Normal acid $\times 0 \cdot 0540 = N_2O_5$	$\bar{2} \cdot 732\ 39$
,, $\times 0 \cdot 1011 = KNO_3$	$\bar{1} \cdot 004\ 75$
Metallic iron $\times 0 \cdot 3761 = HNO_3$	$\bar{1} \cdot 575\ 30$
,, $\times 0 \cdot 6035 = KNO_3$	$\bar{1} \cdot 780\ 68$
,, $\times 0 \cdot 3224 = N_2O_5$	$\bar{1} \cdot 508\ 40$
SILVER ($Ag = 107 \cdot 88$)	
1 c.c. $\frac{N}{10}$ NaCl $= 0 \cdot 010788$ gram Ag . . .	$\bar{2} \cdot 032\ 94$
,, $= 0 \cdot 016989$,, $AgNO_3$ . .	$\bar{2} \cdot 230\ 17$

VOLUMETRIC FACTORS—*continued.*

	Logarithms.
SULPHURETTED HYDROGEN ($H_2S = 34{\cdot}086$)	
1 c.c. $\frac{N}{10}$ arsenious solution = 0·002556 gram H_2S .	$\bar{3}{\cdot}407\ 56$
TIN (Sn = 119)	
Metallic iron × 1·0654 = tin . .	0·027 49
Ferrous ammonium sulphate × 0·1522 = tin . .	$\bar{1}{\cdot}182\ 41$
Factor for $\frac{N}{10}$ iodine or permanganate solution 0·00595	$\bar{3}{\cdot}774\ 52$
ZINC (Zn = 65·37)	
Metallic iron × 0·5852 = Zn . .	$\bar{1}{\cdot}767\ 33$
„ 0·7285 = ZnO .	$\bar{1}{\cdot}862\ 41$
Ferrous ammonium sulphate × 0·0836 = Zn . .	$\bar{2}{\cdot}922\ 21$
„ 0·1041 = ZnO .	$\bar{1}{\cdot}017\ 45$
1 c.c. $\frac{N}{10}$ solution = 0·003268 gram Zn . . .	$\bar{3}{\cdot}514\ 28$

NITROMETER ANALYSIS.

1 c.c. NO at N.T.P.	= 0·6257	mgm.	N . . .	$\bar{1}{\cdot}796\ 34$
„ „	= 1·3402	„	NO . . .	0·127 17
„ „	= 1·6975	„	N_2O_3 . . .	0·229 81
„ „	= 2·4121	„	N_2O_5 . . .	0·382 40
„ „	= 2·8144	„	HNO_3 . .	0·449 39
„ „	= 3·8009	„	KNO_2 . .	0·579 88
„ „	= 4·5154	„	KNO_3 . .	0·654 70
„ „	= 3·0819	„	$NaNO_2$ . .	0·488 82
„ „	= 3·7986	„	$NaNO_3$ . .	0·579 62
„ „	= 5·2294	„	$C_5H_{11}NO_2$ . .	0·718 45
„ „	= 3·3516	„	$C_2H_5NO_2$ . .	0·525 25

Temperature ° C.	For use in Calibrating Instruments.		For use with Standard Solutions.	
	Weight of 1 Litre of Water.	Volume of 1 Gram of Water.	Volume corresponding with 1 Litre at 15° C.	Volume of 1 c.c. reduced to 15° C.
	grams.	c.c.	c.c.	c.c.
5	998·6	1·0014	998·3	1·0017
6	,,	,,	·4	1·0016
7	,,	,,	·5	1·0014
8	,,	,,	·7	1·0013
9	,,	,,	·9	1·0011
10	998·5	1·0015	999·0	1·0010
11	,,	,,	·2	1·0008
12	998·4	1·0016	·4	1·0006
13	·3	1·0017	·6	1·0004
14	·2	1·0018	·8	1·0002
15	·1	1·0019	1000·0	1·0000
16	997·9	1·0021	·2	0·9998
17	·8	1·0022	·4	0·9996
18	·7	1·0023	·6	0·9994
19	·5	1·0025	·8	0·9992
20	·3	1·0027	1001·1	0·9989
21	·2	1·0028	·3	0·9987
22	997·0	1·0030	·6	0·9984
23	996·8	1·0032	·8	0·9982
24	·6	1·0034	1002·0	0·9980
25	·3	1·0037	·3	0·9977

Coefficients of Absorption of Gases in Water.

Gas.	1 volume of Water dissolves at 760 mm. Pressure.					Observer.
	0° C.	4° C.	10° C.	15° C.	20° C.	
Acetylene, . .	1·73	1·53	1·31	1·15	1·03	Winkler
Air *, . . .	0·02882	0·02606	0·02265	0·02046	0·01870	,,
Ammonia, . .	1158·08	1048·23	898·67	770·29†	696·17	Roscoe and Dittmar
Carbon monoxide,	0·03537	0·03219	0·02816	0·02548	0·02319	Winkler
,, dioxide, .	1·713	1·473	1·194	1·019	0·878	Bohr and Bock
Chlorine, . .	3·0362	...	2·5852	2·3681	2·1565	Schönfeld
Hydrogen, . .	0·02148	0·02064	0·01955	0·01883	0·01819	Winkler
,, sulphide,	4·3706	4·0442	3·5858	3·2326	2·9053	Schönfeld
Methane, . .	0·05473	0·05002	0·04366	0·03902	0·03498	Hinrichs
Nitric oxide, .	0·07381	0·06628	0·05709	0·05147	0·04706	Winkler
Nitrous ,, . .	1·3052	1·1346	0·9196	0·7778	0·6700	Carius
Nitrogen, . .	0·02348	0·02130	0·01857	0·01682	0·01542	Winkler
Oxygen, . .	0·04890	0·04397	0·03802	0·03415	0·03102	,,
Sulphur dioxide, .	79·789	69·828	[illegible]	[illegible]	[illegible]	[illegible]

* Calculated from nitrogen and ox

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TABLE OF RECIPROCALS.

No.	Reciprocal.	No.	Reciprocal.	No.	Reciprocal.	No.	Reciprocal.
1	1	31	·03226	61	·01639	91	·01099
2	·5	32	·03125	62	·01613	92	·01087
3	·33333	33	·03030	63	·01587	93	·01075
4	·25	34	·02941	64	·01563	94	·01064
5	·2	35	·02857	65	·01539	95	·01053
6	·16667	36	·02778	66	·01515	96	·01042
7	·14286	37	·02703	67	·01493	97	·01031
8	·125	38	·02632	68	·01471	98	·01020
9	·11111	39	·02564	69	·01449	99	·01010
10	·1	40	·025	70	·01429	100	·01
11	·09091	41	·02439	71	·01409	101	·00990
12	·08333	42	·02381	72	·01389	102	·00980
13	·07692	43	·02326	73	·01370	103	·00971
14	·07143	44	·02273	74	·01351	104	·00962
15	·06667	45	·02222	75	·01333	105	·00952
16	·0625	46	·02174	76	·01316	106	·00943
17	·05882	47	·02128	77	·01299	107	·00935
18	·05556	48	·02083	78	·01282	108	·00926
19	·05263	49	·02041	79	·01266	109	·00917
20	·05	50	·02	80	·0125	110	·00909
21	·04762	51	·01961	81	·01235	111	·00901
22	·04545	52	·01923	82	·01220	112	·00893
23	·04348	53	·01887	83	·01205	113	·00885
24	·04167	54	·01852	84	·01191	114	·00877
25	·04	55	·01818	85	·01177	115	·00870
26	·03846	56	·01786	86	·01163	116	·00862
27	·03704	57	·01754	87	·01149	117	·00855
28	·03571	58	·01724	88	·01136	118	·00847
29	·03448	59	·01695	89	·01124	119	·00840
30	·03333	60	·01667	90	·01111	120	·00833

Ex. 1. $\frac{100}{17} \times \cdot 01 = \frac{1}{17} = 0 \cdot 05882.$

Ex. 2. $\frac{100}{43} \times \cdot 02 = \frac{1}{43} \times 2 = \cdot 02326 \times 2 = 0 \cdot 04652.$

Ex. 3. $\frac{100}{82} \times \cdot 005 = \frac{1}{82} \times \frac{1}{2} = \frac{0 \cdot 0122}{2} = 0 \cdot 0061.$

VARIOUS USEFUL FACTORS.

To convert :—	Multiplier.	Logarithm.
Grams per litre into grains per cubic foot,	437·00	2·640 4754
,, ,, ounces (av.) ,,	0·99884	$\bar{1}$·999 4973
,, ,, lb. ,,	0·06243	$\bar{2}$·795 3773
,, ,, grains per fluid oz.	0·43847	$\bar{1}$·641 9391
,, ,, grains per gallon	70	1·845 0980
Grains per gallon into cwts. per million gallons	1·2755	0·105 6339
,, ,, grams per litre*	0·014286	$\bar{2}$·154 9020
Percentage into grains per fluid oz.	4·375	0·640 9781
Percentage into grains per lb.	70	1·845 0980
Litres into cubic feet	0·035321	$\bar{2}$·548 0345
Cubic inches into gallons	0·003604	$\bar{3}$·556 7949
,, feet ,, ,,	6·2279	0·794 3386
,, yards ,, ,,	168·152	2·225 7026

15·68 grains per gallon = 1 ton per million gallons.

* Or divide by 70.

USEFUL DATA.

Logarithms.

I. *Areas and Volumes of Bodies.*

			Logarithms.
Area of a circle	$=\pi r^2$	r = radius	
		$\pi = 3\cdot1415926$	0·497 1499
Volume of a sphere	$=\frac{4}{3}\pi r^3$	$\frac{4}{3}\pi = 4\cdot1888$	0·622 0886
Volume of a cylinder	$=\pi r^2 h$	r = radius of base	
		h = height	
Surface of sphere	$=4\pi r^2$	$4\pi = 12\cdot5664$	1·099 2099

II. *Specific Gravity.*

To convert :—

(1) Degrees of Twaddell's hydrometer into sp. gr. (water = 1000)—multiply by 5 and add 1000

(2) Sp. gr. (water = 1000) into degrees of Twaddell's hydrometer—subtract 1000 and divide by 5

(3) The sp. gr. of gases referred to atmospheric air as unity $= \frac{34\cdot52 \times \text{mol. wt.}}{1000} = \frac{\text{mol. wt.}}{28\cdot97}$

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1 kilogrammetre = 7·2330 foot-pounds,	0·859 3196
1 foot-pound = 0·13825 kilogrammetres,	$\bar{1}$·140 6804

NOTES ON LOGARITHMS.

Definition.—The logarithm of a number N is the value of x which satisfies the equation $a^x = N$, where a is some given number.

Thus if a be 10 (which is the *base* of Briggs' or the ordinary logarithms), the logarithm of 100 is 2, that of 1000 is 3; and that of any number between 100 and 1000 will be greater than 2 and less than 3, so that it may be represented by 2 followed by places of decimals.

By means of a table of logarithms two numbers may be *multiplied* together by *adding* their logarithms and *divided* by *subtracting* their logarithms, the result in each case being the number corresponding to the logarithm thus obtained. Also Involution, or raising of powers, is performed by multiplication of the logarithm of the number by the index of the power; and Evolution, or extraction of roots, by division of the logarithm of the number by the index of the root.

The integral part of a logarithm is called the *characteristic*, the decimal part the *mantissa*. The characteristic may be either positive or negative (*e.g.*, 2, $\bar{2}$),* but the mantissa is *always positive*. The mantissæ *only* are registered in the tables, the characteristics always being found by the following simple rules :—

(1) For numbers greater than unity, the characteristic is *one less* than the number of digits, and is *positive*.

(2) For numbers less than unity, the characteristic is *one greater* than the number of ciphers which precede the first significant figure, and is *negative*.*

Ex.	Log.	437·58	$= 2{\cdot}6410575$
	Log.	43·758	$= 1{\cdot}6410575$
	Log.	4·3758	$= 0{\cdot}6410575$
	Log.	·43758	$= \bar{1}{\cdot}6410575$
	Log.	·043758	$= \bar{2}{\cdot}6410575$

Negative characteristics are calculated according to the ordinary rules of algebraic addition and subtraction. A few examples will show the methods employed.

(1) Addition—

$$\begin{array}{r} \text{Add } 5{\cdot}3468541 \\ \bar{3}{\cdot}2685427 \\ \hline 2{\cdot}6153968 \end{array}$$

$+5$ added to $\bar{3}$ gives $+2$.

$$\begin{array}{r} \text{Add } 6{\cdot}3874654 \\ \bar{2}{\cdot}9245636 \\ \hline 5{\cdot}3120290 \end{array}$$

$+6$ is increased to $+7$ by the 1 carried over from the mantissæ, and $+7$ added to $\bar{2}$ gives $+5$.

*The negative sign is placed *over* the characteristic to indicate that *it alone* is negative. If placed in front, like an ordinary negative sign, both characteristic and mantissa would become negative.

NOTES ON LOGARITHMS—*continued.*

(1) Addition—*continued.*

$$\begin{array}{ll} \text{Add} & \bar{2}\cdot5632874 \\ & \bar{3}\cdot2465281 \\ \hline & \bar{5}\cdot8098155 \end{array}$$

$$\begin{array}{ll} \text{Add} & \bar{3}\cdot3010300 \\ & \bar{2}\cdot9020029 \\ \hline & \bar{4}\cdot2030329 \end{array}$$

Here the + 1 carried over from the mantissæ is added to $\bar{3}$ giving $\bar{2}$, and $\bar{2}$ added to $\bar{2}$ gives $\bar{4}$.

(2) Subtraction—

Rule.—Change the sign of the characteristic in the lower line, and add as above.

$$\begin{array}{ll} \text{From} & 2\cdot6847658 \\ \text{Subtract} & \bar{3}\cdot2468543 \\ \hline & 5\cdot4379115 \end{array}$$

$\bar{3}$ becomes, on changing its sign, + 3, and this added to + 2 gives + 5.

$$\begin{array}{ll} \text{From} & \bar{2}\cdot3468537 \\ \text{Subtract} & \bar{5}\cdot7654626 \\ \hline & 2\cdot5813911 \end{array}$$

Here 1 is carried over from the mantissæ, and has to be subtracted from $\bar{2}$, giving $\bar{3}$: then changing the $\bar{5}$ into + 5, and adding this to $\bar{3}$, we have + 2.

$$\begin{array}{ll} \text{From} & \bar{5}\cdot6843252 \\ \text{Subtract} & \bar{3}\cdot7856310 \\ \hline & \bar{3}\cdot8986942 \end{array}$$

Here the 1 carried over subtracted from $\bar{5}$ gives $\bar{6}$; then changing $\bar{3}$ into + 3 and adding it to $\bar{6}$, we have $\bar{3}$.

Proportional Parts.—When the logarithm of a number consisting of five figures or less is required, it can be found immediately in the tables; but if the numbers consist of more than five figures, a little calculation is required in order to find its correct logarithm. This calculation is greatly facilitated by the use of a *table of proportional parts.* It will be seen, on reference to the tables, that the differences between the logarithms of numbers differing by 1 in the fifth figure remain remarkably constant for a great many successive numbers, except at the beginning of the tables, where the changes are rather rapid. Thus, from 66500 to 67500 the difference between any two consecutive logarithms is uniformly 65: *e.g.*, log. 66511 (= 4·8228935) subtracted from log. 66512 (= 4·8229000) gives 65. Suppose, then, we require the logarithm of a number consisting of six or seven figures, as for instance 66511·37, how do we proceed to find it?

NOTES ON LOGARITHMS—*continued.*

This is done as follows:—First write down the next lower logarithm.

$$\text{Log. } 66511 = 4{\cdot}8228935,$$

then, since the difference of 1 in the fifth figure makes a difference of 65 in the logarithm, a difference of ·37 will make a difference of $65 \times {\cdot}37 = 24$.

$$\therefore \text{ Log. } 66511{\cdot}37 = 4{\cdot}8228935 + 24 = 4{\cdot}8228959.$$

In the *table of proportional parts,* however, the amount to be added for every tenth of a unit is recorded, and by this table the above result may be easily found thus:—

Log. 66511	=	4·8228085
Proportional part for ·3	=	20
Proportional part for ·07	=	46
		4·82289596

Conversely, the number to six, seven, or more figures corresponding to a given logarithm, is found by a method exactly the converse of that given above.

Example.—Find the number whose log. is 2·9324547.

2·9324547	
2·9324535 = log. 855·96	
12	
10 =	·002
20 =	·0004
	855·9624 the number required.

In the above example the difference between the given log. and the next lower in the tables being 12, the required number will evidently lie between 855·962 and 855·963, since the proportional part for 2 is 10 and that for 3 is 15. Subtracting that for 2, namely 10, we have 2 left. Annex a cipher to the 2, since the figure to be found will occupy the next decimal place, and the number 20 thus obtained is the proportional part for the figure 4.

COMPUTATION.

The following examples will show some of the methods that may be used with great advantage for reducing labour in working out the results of analytical and other chemical work :—

Ex. 1. Multiply 237·2 by 0·9889

$$\cdot 9889 = 1 - \cdot 0111$$

$$\begin{array}{lr}
\text{Hence} & 237{\cdot}2 \\
\hline
\left.\begin{array}{l}\text{less the}\\ \text{sum of}\end{array}\right\} & \begin{array}{r}2{\cdot}372\\ {\cdot}2372\\ {\cdot}02372\end{array} \\
\hline
 & 234{\cdot}56708. \\
\hline
\end{array}$$

Ex. 2. Multiply 578·643 by 2·987

$$2{\cdot}987 = 3 - {\cdot}013$$

$$\begin{array}{lr}
 & 578{\cdot}643 \\
 & 3 \\
\hline
 & 1735{\cdot}929 \\
\hline
\left.\begin{array}{l}\text{less the}\\ \text{sum of}\end{array}\right\} & \begin{array}{r}5{\cdot}78643\\ 1{\cdot}735929\end{array} \\
\hline
 & 1728{\cdot}406641. \\
\hline
\end{array}$$

Ex. 3. Multiply 182·76 by 5

$$= 182{\cdot}76 \times \frac{10}{2} = \frac{1827{\cdot}6}{2} = 913{\cdot}8.$$

Ex. 4. Multiply 32·8 by 15.

$$\begin{array}{r}
= 32{\cdot}8 \times 10 = 328 \\
+\text{half of } 32{\cdot}8 \times 10 = 164 \\
\hline
492 \\
\hline
\end{array}$$

Ex. 5. Multiply 0·07964 by 25

$$= {\cdot}07964 \times \frac{100}{4} = \frac{7{\cdot}964}{4} = 1{\cdot}991.$$

Similarly to multiply by $2\frac{1}{2}$ use the fraction $\frac{10}{4}$.

Ex. 6. $247{\cdot}68 \times 125 = 247{\cdot}68 \times \frac{1000}{8} = \frac{247680}{8}$
$= 30960.$

Similarly to multiply by 12·5 use $\frac{100}{8}$,
and to multiply by ·125, simply divide by 8.

Ex. 7. In like manner, to *divide* by 25,
e.g. $\frac{5768}{25}$. This equals $\frac{5768 \times 4}{100} = 57{\cdot}68 \times 4$
$= 230{\cdot}72.$

APPROXIMATIONS.

In many cases the results of chemical investigations may be regarded as accurate to the second or third decimal place only: hence it is simply misleading (not to say deceptive) to calculate such results to the fourth or fifth place of decimals. In these cases the following methods of obtaining *approximate* results, correct to the first or second place of decimals, will be found invaluable.

Rule for multiplication.—Write the multiplier *backwards* under the multiplicand, and multiply in the usual way, each digit of the multiplier being multiplied into the figure immediately above it, those to the right being ignored, *except* that next to it, from which we get the amount to carry forward.

The amount to be carried forward is taken as the nearest multiple of ten. Thus

any number	from	1 to 4	counts	zero.
„	„	5 to 10	„	1
„	„	10 to 14	„	1
„	„	15 to 20	„	2 and so on.

Omit all decimal points at first, the position of the decimal point in the answer being fixed afterwards,* as shown in the examples below.

Ex. 8. Multiply 47·26 by 12·43, giving four figures in the answer.

```
4726          In the second line 2 × 6 = 12
3421                               .·. carry 1
————            „  third line   4 × 2 = 8
4726                               .·. carry 1
 945            „  fourth line  3 × 7 = 21
 189                               .·. carry 2
  14
————
5874
```

* "When I calculate I seldom trouble my head about the position of the decimal point in my answer until everything else is finished. There are many cleverly-contrived rules about the position of the decimal point, but we forget them in practical work. Better never learn them."—Prof. John Perry, F.R.S.

To find where to put the decimal point, we notice that as 47 is nearly 50, the result will be rather less than $50 \times 12 = 600$. Hence the answer is obviously 587·4.

If greater accuracy had been required, we should have proceeded thus :—

```
47260
 8421
─────
47260
 9452
 1890
  142
─────
58744   Result 587·44.
```

Ex. 9. Multiply 3·72 by ·0005962.

Here we make 3·72 the multiplier as it shortens the work.

```
 5962
  273
─────
17886
 4178
  119
─────
22178
```

As 3·72 is nearly 4, the answer will be rather *less* than $·0006 \times 4 = ·0024$.

Hence the result is ·0022178, or ·00222 correct to the fifth decimal place.

Ex. 10. To find the number of feet in 726·422 metres, given that 1 metre = 3·2808 feet,

```
 726422
  80823
───────
2179266
 145284
  58114
    581
───────
2383245
```

$726 \times 3 = 2178$, hence the answer is clearly 2383·245.

Rule for division.—Proceed as in the ordinary way, but instead of adding zeros to the dividend cut off digits from the divisor, carrying forward a figure from the digit rejected, just as in multiplication.

Ex. 11. Divide 2·71828 by 3·1416.

```
3,1,4,1,6)271828  (86525
          251328
          ------
           20500
           18850
           -----
            1650
            1571
            ----
              79
              63
              --
              16
              15
              --
               1
```

Since $\frac{2 \cdot 7}{3} = 0 \cdot 9$, the answer is evidently 0·86525.

Ex. 12. How many cubic feet would be occupied by 1897·6 gallons of water? (6·228 gallons occupy 1 cubic foot.)

```
6,2,2,8)18976  (3047
        18684
        -----
          292
          249
          ---
           43
           42
           --
            1
```

Note that as 292 is not divisible by 622, we put zero in the quotient and then divide by 62. The result is 304·7.

Ex. 13. How many litres correspond to 6279864 cubic inches? (1 litre = 61·035 cubic inches.)

```
6,1,0,3,5)6279864  (1028896
          61035
          -----
          176864
          122070
          ------
           54294
           48828
           -----
            5466
            4882
            ----
             584
             549
             ---
              35
              36
```

Here, and in similar cases, proceed exactly as in ordinary division until all the figures in the dividend have been brought down, *then* begin to abbreviate. The result is seen at once to be 102889·6.

Examples requiring the use of Logarithms.

Ex. 14. To find a factor to multiply the number of c.c. of normal sulphuric acid required to saturate 20 c.c. of gas-liquor so as to give ounces of H_2SO_4 required per gallon

Let x be the number of c.c. of normal sulphuric acid used.

Then x c.c. contain ·049 x grams of H_2SO_4
·049 x grams for 20 c.c. will be

$$\frac{\cdot 049 \times 4545\cdot 96}{20} x \text{ grams } H_2SO_4 \text{ per gallon}$$

or

$$\frac{\cdot 049 \times 4545\cdot 96}{20 \times 28\cdot 3495} x \text{ ounces } H_2SO_4 \text{ per gallon.}$$

To find the value of the fraction :—

$$\begin{array}{ll} \log.\ \cdot 049 = \bar{2}\cdot 6901961 & \log.\ 20 = 1\cdot 3010300 \\ \ \ ,,\ \ 4545\cdot 96 = 3\cdot 6576260 & \ \ ,,\ \ 28\cdot 3495 = 1\cdot 4525459 \\ \hline \qquad 2\cdot 3478221 & \qquad \underline{2\cdot 7535759} \\ \qquad 2\cdot 7535759 & \\ \hline \qquad \bar{1}\cdot 5942462 = 0\cdot 39287. & \end{array}$$

The log thus obtained may now be abbreviated to $\bar{1}\cdot 59425$. Suppose that 32·8 c.c. of normal H_2SO_4 were required, then

$$\begin{array}{l} \log.\ 32\cdot 8 = 1\cdot 51587 \\ \qquad\qquad \bar{1}\cdot 59425 \\ \hline \qquad\qquad 1\cdot 11012 = 12\cdot 89 \text{ ounces } H_2SO_4 \text{ per gallon.} \end{array}$$

Logarithms should not *always* be used in similar cases, since by cancelling out common factors in numerator and denominator some fractions reduce to very simple forms. Thus in a certain calculation the following factor was required :—

Ex. 15. $\dfrac{480 \times 20 \times 30}{144 \times 7000}$ which readily reduces to $\dfrac{2}{7}$.

INDIRECT ANALYSIS.

The methods used are best shown by examples.

Ex. 1. A mixture of chlorides of potassium and sodium weighs 0·9800 gram, and it contains 0·5633 gram of chlorine : to find the amount of each chloride present.

$$\text{Let} \quad x = \text{weight of NaCl present}$$
$$y = \quad " \quad KCl \quad "$$

1 part by weight of NaCl contains 0·6066 Cl

1 " " KCl " 0·4756 Cl

(See Table of Percentage Compositions.)

$$\therefore \quad x + y = 0·9800 \quad \text{(i)}$$
$$·6066x + ·4756y = 0·5633 \quad \text{(ii)}$$
$$\text{(ii)} \quad ·6066x + ·4756y = 0·5633$$
$$\text{(i)} \times ·4756 \quad ·4756x + ·4756y = 0·4661$$
$$·1310x = 0·0972$$
$$x = \frac{·0972}{·131} = 0·7420 \text{ gram NaCl}$$

From (i) $\quad y = 0·9800 - ·7420 = 0·2380$ gram KCl.

Hence the mixture contains

$$\frac{·742 \times 100}{·98} = 75·71\% \text{ NaCl}$$
$$\text{and } 24·29\% \text{ KCl.}$$

The general rule in this case is found as follows :—

Let w = weight of mixed chlorides of sodium and potassium
s = weight of chlorine
and x = weight of NaCl present.

$$\text{Then } ·6066x + ·4756\,(w - x) = s$$
$$·131x + ·4756\,w = s$$
$$\frac{·131}{·4756}x = \frac{s}{·4756} - w$$
$$\text{or} \quad ·27544x = 2·1026s - w$$
$$x = 3·6305\,(2·1026s - w).$$

Hence the rule :—

Multiply the weight of chlorine present by 2·1026, *and subtract from the product the weight of the mixed chlorides. The remainder multiplied by* 3·6305 *will give the weight of sodium chloride present in the mixture.*

log. 2·1026 = 0·32276 $\qquad$ log. 3·6305 = 0·55997

The above rule gives the best results when the chlorides present are in approximately equal amounts.

Ex. 2. 0·9000 gram of a mixture of calcium and strontium carbonates yields 1·1892 grams of sulphates of calcium and strontium. What is the percentage composition of the mixture of carbonates?

Since $CaCO_3 = 100$ and $CaSO_4 = 136$
1 gram of $CaCO_3$ will yield 1·36 grams $CaSO_4$.
Similarly 1 „ $SrCO_3$ „ 1·244 „ $SrSO_4$.
(See p. 51.)

Then if the mixture contains x grams of $CaCO_3$
and y „ „ $SrCO_3$
x grams $CaCO_3$ become $1·36\ x$ grams $CaSO_4$
and y „ $SrCO_3$ „ $1·244\ y$ „ $SrSO_4$

$$x + y = 0·9000 \qquad \text{(i)}$$
$$1·36x + 1·244y = 1·1892 \qquad \text{(ii)}$$
$$\text{(i)} \times 1·36 \qquad 1·36x + 1·360y = 1·2240$$
$$\text{(ii)} \qquad 1·36x + 1·244y = 1·1892$$
$$·116y = ·0348$$
$$y = \frac{·0348}{·116} = 0·300$$
$$x = ·9 - ·3 = ·6$$

Hence the mixture consisted of

$$\frac{·3 \times 100}{·9} = 33·33\% \text{ calcium carbonate}$$
and 66·67% strontium carbonate.

FORMULÆ, MOLECULAR WEIGHTS, AND PERCENTAGE COMPOSITIONS OF COMMONLY OCCURRING COMPOUNDS.

C = crystallized.   A = anhydrous.

Name.	Formula.	Molecular Weight.	Percentage Composition.
ALUMINIUM (Al = 27·1)			
Aluminium chloride, . . .	Al_2Cl_6	266·96	Al 20·30 ; Cl 79·70
,, hydroxide, . .	$Al_2(OH)_6$	156·248	Al 65·41 ; H_2O 34·59
,, oxide, . . .	Al_2O_3	102·2	Al 53·03 ; O 46·97
,, sulphate, . .	$Al_2(SO_4)_3$, $18H_2O$	(C) 666·698 (A) 342·410	Al_2O_3 15·38 ; SO_3 36·03 ; H_2O 48·64
Alum (ammonia) . . .	$Al_2(NH_4)_2(SO_4)_4$, $24H_2O$	(C) 906·948 (A) 474·564	Al_2O_3 11·27 ; NH_3 3·76 ; SO_3 35·31 ; H_2O 47·66
,, (potash), ...	$Al_2K_2(SO_4)_4$, $24H_2O$	(C) 949·064 (A) 516·680	Al_2O_3 10·77 ; K_2O 9·93 ; SO_3 33·75 ; H_2O 45·55
AMMONIUM (NH_4 = 18·042)			
Ammonia, ...	NH_3	17·034	N 82·25 ; H 17·75
Ammonium bromide, . .	NH_4Br	97·962	NH_3 17·39 ; HBr 82·61
,, carbonate, . .	$(NH_4)HCO_3$ + $NH_2.COO(NH_4)$	157·118	NH_3 32·52 ; CO_2 56·01 ; H_2O 11·47
,, chloride, . .	NH_4Cl	53·502	NH_3 31·84 ; HCl 68·16
,, nitrate, . . .	NH_4NO_3	80·052	NH_3 21·27 ; HNO_3 78·73
,, oxalate, . . .	$(NH_4)_2C_2O_4.H_2O$	(C) 142·100 (A) 124·084	(A) NH_3 27·46 ; $H_2C_2O_4$ 72·54
,, phosphate, . .	$(NH_4)_2HPO_4$	132·132	NH_3 25·78 ; P_2O_5 53·76 ; H_2O 20·46
,, sulphate, . .	$(NH_4)_2SO_4$	132·154	NH_3 25·78 ; H_2SO_4 74·22
,, thiocyanate, . .	NH_4CNS	76·122	NH_3 22·38 ; H 1·32 ; CN 34·17 ; S 42·13

Antimony (Sb=120·2)			
Antimony trichloride,	$SbCl_3$	226·58	Sb 53·05 ; Cl 46·95
Antimonious oxide,	Sb_2O_3	288·4	Sb 83·36 ; O 16·64
Antimony tetroxide,	Sb_2O_4	304·4	Sb 78·98 ; O 21·02
,, trisulphide,	Sb_2S_3	336·61	Sb 71·42 ; S 28·58
Arsenic (As=74·96)			
Arsenic trichloride,	$AsCl_3$	181·34	As 41·34 ; Cl 58·66
Arsenious oxide,	As_4O_6	395·84	As 75·75 ; O 24·25
Arsenic trisulphide,	As_2S_3	246·13	As 60·91 ; S 39·09
,, pentoxide,	As_2O_5	229·92	As 65·21 ; O 34·79
Barium (Ba=137·37)			
Barium carbonate,	$BaCO_3$	197·37	BaO 77·71 ; CO_2 22·29
,, chloride,	$BaCl_2, 2H_2O$	(C) 244·322 (A) 208·290	(C) $BaCl_2$ 85·25 ; H_2O 14·75 (A) Ba 65·95 ; Cl 34·05
,, nitrate,	$Ba(NO_3)_2$	261·39	BaO 58·67 ; N_2O_5 41·33
,, oxide,	BaO	153·37	Ba 89·57 ; O 10·43
,, hydroxide,	$Ba(OH)_2, 8H_2O$	(C) 315·514 (A) 171·386	BaO 48·61 ; H_2O 51·39
,, sulphate,	$BaSO_4$	233·44	BaO 65·70 ; SO_3 34·30
Bismuth (Bi=208)			
Bismuth chloride,	$BiCl_3$	314·38	Bi 66·16 ; Cl 33·84
,, oxide,	Bi_2O_3	464	Bi 89·66 ; O 10·34
,, nitrate,	$Bi(NO_3)_3, 5H_2O$	(C) 484·11 (A) 394·03	$Bi(NO_3)_3$ 81·39 ; H_2O 18·61
Boron (B=11)			
Boric anhydride,	B_2O_3	70	B 31·43 ; O 68·57
,, acid,	H_3BO_3	62·024	B_2O_3 56·43 ; H_2O 43·57

FORMULÆ, MOLECULAR WEIGHTS, AND PERCENTAGE COMPOSITIONS OF COMMONLY OCCURRING COMPOUNDS—*continued.*

C = crystallized. A = anhydrous.

Name.	Formula.	Molecular Weight.	Percentage Composition.
CADMIUM (Cd = 112·4)			
Cadmium chloride, . . .	$CdCl_2, H_2O$	(C) 201·336 (A) 183·320	$CdCl_2$ 91·05 ; H_2O 8·95
,, oxide, . . .	CdO	128·4	Cd 87·54 ; O 12·46
,, sulphide, . . .	CdS	144·47	Cd 77·80 ; S 22·20
CALCIUM (Ca = 40·07)			
Calcium chloride, . . .	$CaCl_2, 6H_2O$	(C) 219·086 (A) 110·990	(A) Ca 36·10 ; Cl 63·90
,, carbonate, . . .	$CaCO_3$	100·07	CaO 56·08 ; CO_2 43·97
,, fluoride, . . .	CaF_2	78·07	Ca 51·33 ; F 48·67
,, hydroxide, . . .	$Ca(OH)_2$	74·086	CaO 75·68 ; H_2O 24·32
,, nitrate, . . .	$Ca(NO_3)_2, 4H_2O$	(C) 236·154 (A) 164·090	(A) CaO 34·17 ; N_2O_5 65·83
,, oxide, ...	CaO	56·07	Ca 71·46 ; O 28·54
Calcium sulphate, . . .	$CaSO_4, 2H_2O$	(C) 172·172 (A) 136·140	(C) CaO 32·57 ; SO_3 46·51 ; H_2O 20·92 (A) CaO 41·19 ; SO_3 58·81
Monocalcium phosphate, . .	$CaH_4(PO_4)_2$	234·182	CaO 23·94 ; P_2O_5 60·67 ; H_2O 15·39
Tricalcium ,, . .	$Ca_3(PO_4)_2$	310·29	CaO 54·21 ; P_2O_5 45·79
Calcium sulphide, . . .	CaS	72·14	Ca 55·54 ; S 44·46
CARBON (C = 12)			
Carbon monoxide, . . .	CO	28	C 42·86 ; O 57·14
,, dioxide, . . .	CO_2	44	C 27·27 ; O 72·73

CHROMIUM ($Cr=52$)			
Chromic chloride, . . .	Cr_2Cl_6	316·76	Cr 32·83 ; Cl 67·17
,, oxide, ...	Cr_2O_3	152	Cr 68·42 ; O 31·58
,, sulphate, . . .	$Cr_2(SO_4)_3$	392·21	Cr_2O_3 38·75 ; SO_3 61·25
COBALT ($Co=58·97$)			
Cobaltous chloride, . . .	$CoCl_2$	129·89	Co 45·40 ; Cl 54·60
,, nitrate, . . .	$Co(NO_3)_2, 3H_2O$	(C) 237·038 (A) 182·990	CoO 31·63 ; N_2O_5 45·57 ; H_2O 22·80
Cobalt monoxide, . . .	CoO	74·97	Co 78·66 ; O 21·34
COPPER ($Cu=63·57$)			
Cuprous chloride, . . .	Cu_2Cl_2	198·06	Cu 64·19 ; Cl 35·81
,, oxide, ...	Cu_2O	143·14	Cu 88·82 ; O 11·18
,, sulphide, . . .	Cu_2S	159·21	Cu 79·86 ; S 20·14
Cupric chloride, . . .	$CuCl_2, 2H_2O$	(C) 170·522 (A) 134·490	(A) Cu 47·27 ; Cl 52·73
,, oxide, ...	CuO	79·57	Cu 79·89 ; O 20·11
,, sulphide, . . .	CuS	95·64	Cu 66·47 ; S 33·53
,, sulphate, . . .	$CuSO_4, 5H_2O$	(C) 249·72 (A) 159·64	CuO 31·86 ; SO_3 32·06 ; H_2O 36·08
HYDROGEN ($H=1·008$)			
Hydrogen chloride, . . .	HCl	36·468	H 2·76 ; Cl 97·24
,, bromide, . . .	HBr	80·928	H 1·25 ; Br 98·75
,, iodide, . . .	HI	127·928	H 0·79 ; I 99·21
,, nitrate, . . .	HNO_3	63·018	N_2O_5 85·71 ; H_2O 14·29
,, sulphate, . . .	H_2SO_4	98·086	SO_3 81·63 ; H_2O 18·37

FORMULÆ, MOLECULAR WEIGHTS, AND PERCENTAGE COMPOSITIONS OF COMMONLY OCCURRING COMPOUNDS—*continued.*

C=crystallized. A=anhydrous.

Name.	Formula.	Molecular Weight.	Percentage Composition.
IRON ($Fe=55·84$)			
Ferrous chloride,	$FeCl_2$	126·76	Fe 44·05 ; Cl 55·95
,, carbonate,	$FeCO_3$	115·84	FeO 62·02 ; CO_2 37·98
,, oxide,	FeO	71·84	Fe 77·73 ; O 22·27
,, sulphate,	$FeSO_4, 7H_2O$	(C) 278·022 (A) 151·910	FeO 25·84 ; SO_3 28·80 ; H_2O 45·36
,, ammonium sulphate,	$Fe(NH_4)_2(SO_4)_2, 6H_2O$	(C) 392·160 (A) 284·064	0·7023 gm. contains 0·1 gm. Fe
,, sulphide,	FeS	87·91	Fe 63·52 ; S 36·48
Ferric chloride,	Fe_2Cl_6	324·44	Fe 34·42 ; Cl 65·58
,, oxide,	Fe_2O_3	159·68	Fe 69·94 ; O 30·06
Triferric tetroxide,	Fe_3O_4	231·52	Fe 72·36 ; O 27·64
Iron disulphide,	FeS_2	119·98	Fe 46·54 ; S 53·46
Ferric sulphate,	$Fe_2(SO_4)_3$	399·89	Fe_2O_3 39·93 ; SO_3 60·07
LEAD ($Pb=207·1$)			
Lead acetate,	$Pb(C_2H_3O_2)_2, 3H_2O$	(C) 379·196 (A) 325·148	$Pb(C_2H_3O_2)_2$ 85·75 ; H_2O 14·25
,, carbonate,	$PbCO_3$	267·1	PbO 83·53 ; CO_2 16·47
,, chloride,	$PbCl_2$	278·02	Pb 74·49 ; Cl 25·51
,, chromate,	$PbCrO_4$	323·1	PbO 69·05 ; CrO_3 30·95
,, nitrate,	$Pb(NO_3)_2$	331·12	PbO 67·38 ; N_2O_5 32·62
Plumbic oxide,	PbO	223·1	Pb 92·83 ; O 7·17
,, dioxide,	PbO_2	239·1	Pb 86·62 ; O 13·38
Triplumbic tetroxide,	Pb_3O_4	685·3	Pb 90·66 ; O 9·34
Lead sulphide,	PbS	239·17	Pb 86·59 ; S 13·41
,, sulphate,	$PbSO_4$	303·17	PbO 73·59 ; SO_3 26·41

MAGNESIUM ($Mg=24{\cdot}32$)			
Magnesium chloride,	$MgCl_2, 6H_2O$	(C) 203·336 (A) 95·240	(A) Mg 25·54 ; Cl 74·46
,, carbonate,	$MgCO_3$	84·32	MgO 47·82 ; CO_2 52·18
,, oxide,	MgO	40·32	Mg 60·32 ; O 39·68
,, nitrate,	$Mg(NO_3)_2, 6H_2O$	(C) 256·436 (A) 148·340	(A) MgO 27·18 ; N_2O_5 72·82
,, sulphate,	$MgSO_4, 7H_2O$	(C) 246·502 (A) 120·390	MgO 16·36 ; SO_3 32·48 ; H_2O 51·16
Magnesium ammonium phosphate	$Mg_2(NH_4)_2(PO_4)_2, 12H_2O$	(C) 490·996 (A) 274·804	
,, pyrophosphate,	$Mg_2P_2O_7$	222·72	MgO 36·21 ; P_2O_5 63·79
MANGANESE ($Mn=54{\cdot}93$)			
Manganous carbonate,	$MnCO_3$	114·93	MnO 61·72 ; CO_2 38·28
,, chloride,	$MnCl_2, 4H_2O$	(C) 197·914 (A) 125·850	(A) Mn 43·65 ; Cl 56·35
,, oxide,	MnO	70·93	Mn 77·44 ; O 22·56
,, sulphate,	$MnSO_4, 5H_2O$	(C) 241·08 (A) 151·00	(A) MnO 46·97 ; SO_3 53·03
,, sulphide,	MnS	87·00	Mn 63·14 ; S 36·86
Manganese dioxide,	MnO_2	86·93	Mn 63·19 ; O 36·81
,, sesquioxide,	Mn_2O_3	157·86	Mn 69·59 ; O 30·41
Trimanganic tetroxide,	Mn_3O_4	228·79	Mn 72·03 ; O 27·97
MERCURY ($Hg=200{\cdot}6$)			
Mercurous chloride,	Hg_2Cl_2	472·12	Hg 84·98 ; Cl 15·02
,, nitrate,	$Hg_2(NO_3)_2, 2H_2O$	(C) 561·252 (A) 525·220	Hg_2O 74·33 ; N_2O_5 19·25 ; H_2O 6·42
,, oxide,	Hg_2O	417·2	Hg 96·16 ; O 3·84
Mercuric chloride,	$HgCl_2$	271·52	Hg 73·88 ; Cl 26·12

FORMULÆ, MOLECULAR WEIGHTS, AND PERCENTAGE COMPOSITIONS OF COMMONLY OCCURRING COMPOUNDS—*continued*.

C = crystallized. A = anhydrous.

Name.	Formula.	Molecular Weight.	Percentage Composition.
MERCURY ($Hg = 200 \cdot 6$)—*contd.*			
Mercuric nitrate, . . .	$2Hg(NO_3)_2, H_2O$	(C) 667·256 (A) 649·240	HgO 64·92 ; N_2O_5 32·38 ; H_2O 2·70
,, oxide, ...	HgO	216·6	Hg 92·61 ; O 7·39
,, sulphide, . . .	HgS	232·67	Hg 86·22 ; S 13·78
,, sulphate, . . .	$HgSO_4$	296·67	HgO 73·01 ; SO_3 26·99
NICKEL ($Ni = 58 \cdot 68$)			
Nickel chloride, . . .	$NiCl_2$	129·6	Ni 45·28 ; Cl 54·72
,, monoxide, . . .	NiO	74·68	Ni 78·58 ; O 21·42
,, sulphate, . . .	$NiSO_4, 7H_2O$	(C) 280·862 (A) 154·750	NiO 26·59 ; SO_3 28·51 ; H_2O 44·90
,, monosulphide, . .	NiS	90·75	Ni 64·66 ; S 35·34
,, nitrate, ...	$Ni(NO_3)_2, 6H_2O$	(C) 290·796 (A) 182·700	$Ni(NO_3)_2$ 62·83 ; H_2O 37·17
PHOSPHORUS ($P = 31 \cdot 04$)			
Hypophosphorous acid, . .	$HP(OH)_2$	66·064	
Phosphorous ,, . .	H_2PHO_3	82·064	
Phosphoric ,, . .	H_3PO_4	98·064	P_2O_5 72·44 ; H_2O 27·56
Metaphosphoric ,, . .	HPO_3	80·048	P_2O_5 88·75 ; H_2O 11·25
Pyrophosphoric ,, . .	$H_4P_2O_7$	178·112	P_2O_5 79·77 ; H_2O 20·23
Phosphorus pentoxide, . .	P_2O_5	142·08	P 43·69 ; O 56·31
PLATINUM ($Pt = 195 \cdot 2$)			
Platinum tetrachloride, . .	$PtCl_4$	337·04	Pt 57·92 ; Cl 42·08
Ammonium platino-chloride, .	$(NH_4)_2PtCl_6$	444·044	Pt 43·96 ; NH_3 7·67 (N 6·31)
Potassium ,, .	K_2PtCl_6	486·16	Pt 40·15 ; Cl 43·77 ; K 16·08 (KCl 30·67 = K_2O 19·38)

POTASSIUM (K=39·1)			
Potassium acetate, . . .	$KC_2H_3O_2$	98·124	
,, bromide, . . .	KBr	119·02	K 32·85 ; Br 67·15
,, carbonate, . . .	K_2CO_3	138·2	K_2O 68·16 ; CO_2 31·84
,, bicarbonate, . .	$KHCO_3$	100·108	K_2O 47·05 ; CO_2 43·95 ; H_2O 9·00
,, chlorate, . . .	$KClO_3$	122·56	K 31·90 ; Cl 28·93 ; O 39·17
,, chloride, . . .	KCl	74·56	K 52·44 ; Cl 47·56
,, cyanide, . . .	KCN	65·11	K 60·05 ; CN 39·95
,, chromate, . . .	K_2CrO_4	194·2	K_2O 48·51 ; CrO_3 51·49
,, dichromate, . .	$K_2Cr_2O_7$	294·2	K_2O 32·02 ; CrO_3 67·98
,, ferrocyanide, . .	$K_4Fe(CN)_6, 3H_2O$	(C) 422·348 (A) 368·300	K 37·03 ; Fe 13·22 ; CN 36·95 ; H_2O 12·80
,, ferricyanide, . .	$K_3Fe(CN)_6$	329·2	K 35·63 ; Fe 16·96 ; CN 47·41
,, hydroxide, . .	KOH	56·108	K_2O 83·95 ; H_2O 16·05
,, iodide, . . .	KI	166·02	K 23·55 ; I 76·45
,, nitrate, . . .	KNO_3	101·11	K_2O 46·58 ; N_2O_5 53·42
,, nitrite, . . .	KNO_2	85·11	K_2O 55·34 ; N_2O_3 44·66
,, oxide, . . .	K_2O	94·2	K 83·01 ; O 16·99
,, permanganate, . .	$KMnO_4$	158·03	K_2O 29·80 ; Mn_2O_7 70·20
,, sulphate, . . .	K_2SO_4	174·27	K_2O 54·05 ; SO_3 45·95
,, bisulphate, . .	$KHSO_4$	136·178	K_2O 34·59 ; SO_3 58·80 ; H_2O 6·61
,, sulphide, . . .	K_2S	110·27	K 70·92 ; S 29·08
,, sulphite, . . .	$K_2SO_3, 2H_2O$	(C) 194·302 (A) 158·270	K_2O 48·48 ; SO_2 32·97 ; H_2O 18·55
,, thiocyanate, . .	$KCNS$	97·18	K 40·23 ; CNS 59·77
SILICON (Si=28·3)			
Silica, ...	SiO_2	60·3	Si 46·93 ; O 53·07
SILVER (Ag=107·88)			
Silver bromide, . . .	$AgBr$	187·8	Ag 57·44 ; Br 42·56
,, chloride, . . .	$AgCl$	143·34	Ag 75·26 ; Cl 24·74

FORMULÆ, MOLECULAR WEIGHTS, AND PERCENTAGE COMPOSITIONS OF COMMONLY OCCURRING COMPOUNDS—*continued*.

C = crystallized. A = anhydrous.

Name.	Formula.	Molecular Weight.	Percentage Composition.
SILVER ($Ag = 107 \cdot 88$)—*contd.*			
Silver nitrate,	$AgNO_3$	169·89	Ag 63·50 ; NO_3 36·50
,, sulphide,	Ag_2S	247·88	Ag 87·06 ; S 12·94
,, sulphate,	Ag_2SO_4	311·88	Ag_2O 74·32 ; SO_3 25·68
SODIUM ($Na = 23$)			
Sodium acetate,	$NaC_2H_3O_2, 3H_2O$	(C) 136·072	
,, aluminate,	$Na_2Al_2O_4$	164·2	Na_2O 37·76 ; Al_2O_3 62·24
,, borate,	$Na_2B_4O_7, 10H_2O$	(C) 382·16 (A) 202	(C) Na_2O 16·22 ; B_2O_3 36·64 ; H_2O 47·14 (A) Na_2O 30·69 ; B_2O_3 69·31
,, carbonate,	$Na_2CO_3, 10H_2O$	(C) 286·16 (A) 106	(C) Na_2O 21·67 ; CO_2 15·37 ; H_2O 62·96 (A) Na_2O 58·49 ; CO_2 41·51
,, bicarbonate,	$NaHCO_3$	84·008	Na_2O 36·90 ; CO_2 52·38 ; H_2O 10·71
,, chloride,	$NaCl$	58·46	Na 39·34 ; Cl 60·66
,, chromate,	Na_2CrO_4	162	Na_2O 38·27 ; CrO_3 61·73
,, hydroxide,	$NaOH$	40·008	Na_2O 77·48 ; H_2O 22·52
,, nitrate,	$NaNO_3$	85·01	Na_2O 36·47 ; N_2O_5 63·53 (N 16·48)
,, nitrite,	$NaNO_2$	69·01	Na_2O 44·92 ; N_2O_3 55·08
,, oxide,	Na_2O	62	Na 74·19 ; O 25·81
,, phosphate,	$Na_2HPO_4, 12H_2O$	(C) 358·240 (A) 142·048	Na_2O 17·31 ; P_2O_5 19·83 ; H_2O 62·86

SODIUM ($Na=23$)—*continued.*			
Sodium sulphide,	Na_2S	78·07	Na 58·92 ; S 41·08
,, sulphite,	$Na_2SO_3, 7H_2O$	(C) 252·182 (A) 126·07	Na_2O 24·59 ; SO_2 25·41 ; H_2O 50·00
,, thiosulphate,	$Na_2S_2O_3, 5H_2O$	(C) 248·22 (A) 158·14	Na_2O 24·98 ; S 12·92 ; SO_2 25·81 ; H_2O 36·29
STRONTIUM ($Sr=87·63$)			
Strontium carbonate,	$SrCO_3$	147·63	SrO 70·20 ; CO_2 29·80
,, chloride,	$SrCl_2, 6H_2O$	(C) 266·646 (A) 158·550	Sr 32·86 ; Cl 26·60 ; H_2O 40·54
,, nitrate,	$Sr(NO_3)_2$	211·65	SrO 48·96 ; N_2O_5 51·04
,, oxide,	SrO	103·63	Sr 84·56 ; O 15·44
SULPHUR ($S=32·07$)			
Sulphur dioxide,	SO_2	64·07	S 50·05 ; O 49·95
,, trioxide,	SO_3	80·07	S 40·05 ; O 59·95
Sulphuretted hydrogen,	H_2S	34·086	H 5·91 ; S 94·09
TIN ($Sn=119$)			
Stannous chloride,	$SnCl_2, 2H_2O$	(C) 225·952 (A) 189·92	Sn 52·67 ; Cl 31·39 ; H_2O 15·94
,, oxide,	SnO	135	Sn 88·15 ; O 11·85
Stannic oxide,	SnO_2	151	Sn 78·81 ; O 21·19
ZINC ($Zn=65·37$)			
Zinc carbonate,	$ZnCO_3$	125·37	ZnO 64·90 ; CO_2 35·10
,, chloride,	$ZnCl_2$	136·29	Zn 47·96 ; Cl 52·04
,, oxide,	ZnO	81·37	Zn 80·34 ; O 19·66
,, sulphate,	$ZnSO_4, 7H_2O$	(C) 287·552 (A) 161·44	(C) ZnO 28·30 ; SO_3 27·85 ; H_2O 43·85 (A) ZnO 50·40 ; SO_3 49·60
,, sulphide,	ZnS	97·44	Zn 67·09 ; S 32·91
WATER,	H_2O	18·016	H 11·19 ; O 88·81

NOTES ON INDICATORS.

I.—**Litmus solution.**—A solution of a carbonate whilst being titrated should be boiled to expel the free CO_2, otherwise it is easy to overstep the exact point of neutrality. The titration cannot be done by gas-light.

According to B. Reinitzer (see Abstract, *Analyst*, 1894, p. 255) litmus is the most serviceable indicator, excelling methyl orange in sharpness of change of colour and sensitiveness, while it possesses an advantage over phenol-phthalein in being capable of being used in the presence of ammonium salts. Good litmus should be used; the solution must be boiled for seven or eight minutes and then neutralized with HCl, so that the wine-red colour remains even on further boiling: the solution is then cooled, and an equal volume of strong alcohol added. The stock solution should be kept in a bottle with a delivery pipette inserted through the cork. The final change of colour is sharpest when the liquid to be titrated is boiled for seven or eight minutes and then well cooled. Lunge has found (see Abstract *Analyst*, 1895, p. 65) that litmus is only twice as sensitive as methyl orange, against eight times as claimed by Reinitzer. With normal acid practically identical results are obtained, but methyl orange is preferable on account of its speed and the precautions to be observed in the use of litmus. It is only with decinormal acid that litmus is undoubtedly superior, and Reinitzer's method of titration must be observed. Whatever indicator be used, the fluid must be cold when titrated.

If it is desired to titrate carbonates, using litmus or phenol-phthalein as indicator, the boiling should be carried out in vessels of porcelain, platinum or silver; for even Jena glass is attacked by hot soda solutions (Lunge).

II.—**Methyl orange** (the sodium salt of dimethyl-amido-azo-benzene-sulphonic acid).

Solution.—One gram in a litre of distilled water.

Unlike litmus, this indicator is unaffected by CO_2, H_2S, boric, arsenious, hydrocyanic, oleic, stearic, palmitic, and carbolic acids, &c. It must not be used for organic acids; nor in the presence of nitrous acid or nitrites, which decompose it. It acts admirably with mineral acids, and with ammonia and its salts. Ordinary temperatures should be observed.

Colour reaction.—Faint yellow if alkaline, pink if acid.

The use of methyl orange is recommended by Lunge (1903) for all cases except that of weak acids, for which phenol-phthalein should be employed. The strength of solutions titrated should not be less than one-fifth normal.

As methyl orange is often adulterated with dextrin and other substances, every new lot purchased should be carefully tested, especially as to whether it gives a sharp change of colour with a mineral acid.

III.—**Phenol-phthalein** ($C_{20}H_{14}O_4$).

Solution.—Dissolve 4 grams in 600 c.c. of strong alcohol, then add gradually with constant stirring 400 c.c. of distilled water.

It is useless for the titration of free ammonia or its compounds, or for the fixed alkalies when salts of ammonia are present. Unlike methyl orange, it is specially useful in titrating all varieties of organic acids—viz., oxalic, acetic, citric, tartaric, &c. It may be used either in alcoholic solutions or in mixtures of alcohol and ether. It gives no colour with bicarbonates.

Colour reaction.—Colourless in neutral or acid liquids, but rendered purple-red by faint excess of caustic alkali.

IV.—**Cochineal solution.**

Solution.—Digest one part of powdered cochineal with 10 parts of 25 per cent. alcohol.

It is not very much modified in colour by CO_2, and may be used by gas-light. Most useful in titrating solutions of the alkaline earths, such as lime and baryta-water. Inapplicable in the presence of even traces of Fe or Al compounds or acetates.

Colour reaction.—Turned violet by alkalies; the original yellowish-red colour being restored by mineral acids.

V.—**Phenacetolin.**

Solution.—Two grams in a litre of alcohol.

This indicator may be used to estimate the amount of KHO or NaHO in the presence of K_2CO_3 or Na_2CO_3, or of CaO in the presence of $CaCO_3$.

Colour reaction.—

With NH_3 and normal alkaline carbonates—dark pink.
" bicarbonates —intense pink.
" mineral acids —golden yellow.

VI.—**Rosolic Acid** ($C_{20}H_{16}O_3$).

Solution.—Two grams in a litre of 50 per cent. alcohol.

This indicator is excellent for all the mineral, but useless for the organic acids, except oxalic. It may be relied on for the neutralization of SO_2 with ammonia to normal sulphite.

Colour reaction.—The pale yellow colour is unaffected by acids, but changed to violet-red by alkalies.

VII.—**Lacmoid.**

Solution.—Three grams may be dissolved in a litre of dilute alcohol, but Förster recommends the addition of 5 grams of naphthol green to the above. The effect is to produce a more decided blue colour with alkalies than is given by lacmoid alone.

Colour reaction.—Blue in alkaline, red in acid, solution.

VIII.—**Congo Red.**

Solution.—One gram in 100 c.c. of 10 per cent. alcohol. Specially useful in determining free mineral acids in the presence of most organic acids.

Colour reaction.—Red in alkaline solution, turning blue with excess of acid.

Turmeric Paper.—Digest one part of powdered turmeric with six parts of weak alcohol, filter, and steep some filter paper in the filtrate. The paper, when dry, must exhibit a fine yellow tint, and be readily wetted by aqueous fluids. Cut into strips and keep in a well-stoppered bottle covered with black paper.

THE PRECIPITATING POWERS OF A FEW COMMON REAGENTS.

1. Ammonium oxalate. $(NH_4)_2C_2O_4, OH_2$.

40 grams per litre.

For 1 gram taken

10 c.c.	will precipitate	15·78	per cent.	CaO.
„	„	28·17	„	$CaCO_3$.
„	„	38·31	„	$CaSO_4$.
„	„	29·11	„	$Ca_3P_2O_8$.

2. Barium chloride. $BaCl_2, 2OH_2$.

100 grams per litre.

For 1 gram taken

10 c.c.	will precipitate	13·11	per cent.	S.
„	„	32·79	„	SO_3.
„	„	40·16	„	H_2SO_4.
„	„	55·74	„	$CaSO_4$.

3. Hydrogen disodium phosphate. $Na_2HPO_4, 12OH_2$.

100 grams per litre.

For 1 gram taken

10 c.c.	will precipitate	11·17	per cent.	MgO.
„	„	23·46	„	$MgCO_3$.
„	„	33·51	„	$MgSO_4$.

4. Magnesia Mixture.

Dissolve 40 grams of "Magnesia" in HCl, and add a solution of 200 grams of NH_4Cl in the least possible quantity of water. Add 0·960 ammonia till a slight precipitate forms, and filter. Make up the clear filtrate to 1500 c.c. with distilled water, and add 750 c.c. 0·960 ammonia. Shake well, allow to stand, and filter for use. This solution remains clear on diluting with fairly strong ammonia, and for 1 gram of a substance taken

10 c.c. will precipitate 60 per cent.* $Ca_3P_2O_8$.

Thus, if 1 gram of a Belgian Phosphate were taken for analysis, 10 c.c. would doubtless be sufficient to precipitate the P_2O_5 present, but 15 c.c. would be the proper amount to add, the excess being tested for in the filtrate in the usual way.

5. Ammonium molybdate solution.

Dissolve 50 grams of ammonium molybdate in 200 c.c. of ·960 ammonia at a gentle heat, and pour into a mixture of 400 c.c. strong nitric acid, and 400 c.c. water contained in a beaker standing in water, adding the molybdate solution slowly with constant stirring. Allow the solution to stand, and filter for use.

100 c.c. will precipitate 0·10 gram P_2O_5.

* The strength of each batch should be determined and marked on the stock bottle. It usually comes out about 65 per cent.

I. Imperial System.

Avoirdupois Weight.

16 drams (dr.)	=1 ounce (oz.) =487·5 grains*		log. 487·5=2·640 9781
16 ounces	=1 pound (lb.)=7000 ,,		log. 7000 =3·845 0980
14 pounds	=1 stone		
28 ,,	=1 quarter		
100 ,,	=1 cental		
4 quarters	=1 hundredweight (cwt.)=	112 lb.	log. 112=2·049 2180
20 cwts.	=1 ton	=2240 lb.	log. 2240=3·350 2480

Note.—1 dram=27·34375 grains (log. 1·436 8581).

24 grains (and its multiples 48, 72, 120, and 240 grains) are legal weights and are commonly called *pennyweights*.

Troy Weight.

1 troy ounce (oz. tr.)=480 grains* | log. 2·681 2412

Weights less than a troy ounce are expressed as decimals of an ounce, not in grains. For greater weights, ounces only are used, there being *no* troy pound.

Apothecaries' Weight.

20 grains* (gr.)	=1 scruple (℈)
3 scruples or 60 grains	=1 drachm (ʒ)
8 drachms or 480 grains	=1 ounce (℥)

Apothecaries' Measures.

60 minims (min.)	=1 fluid drachm (fl. dr. or *f* ʒ)
8 fluid drachms	=1 fluid ounce (fl. oz. or *f* ℥)
20 fluid ounces	=1 pint (O)†
8 pints	=1 gallon (C)‡

Relations of Apothecaries' Measures to Weights.

(All liquids to be measured at 62° Fah.)

				Logarithms.
1 minim is the measure of	0·9115	grain weight of water		$\bar{1}$·959 7368
1 fluid drachm ,,	54·687	grains	,,	1·737 8881
1 fluid ounce ,,	437·5	,,	,,	2·640 9781
1 pint ,,	8750	,,	,,	3·942 0081
1 gallon ,,	70000§	,,	,,	4·845 0980

1 pint = 34·6829 cubic inches	1·540 1151
1 gallon=277·463 ,, ...	2·443 2051
1 gallon=0·16057 cubic foot	$\bar{1}$·205 6614

Cubic inches × 0·02883 =pints	$\bar{2}$·459 8849
,, × 0·003604=gallons	$\bar{3}$·556 7949
Cubic feet × 6·228 =gallons	0·794 3386

* The grain is common to Avoirdupois, Troy, and Apothecaries' Weights.

† O=octarius, *i.e.*, one-eighth ‡ C=(Roman) Congius.

§ According to H. J. Chaney

One gallon once distilled water weighs 70000·5 grains.

,, twice ,, ,, 70000·0 ,,

,, well water weighs 70066·6 ,,

WEIGHTS AND MEASURES—*continued.*

Long Measure.

12 inches	=1 foot	4 poles	=1 chain
3 feet	=1 yard	40 poles	=1 furlong
6 feet	=1 fathom	8 furlongs	=1 mile=1760 yards
$5\frac{1}{2}$ yards	=1 rod, pole, or perch		

Square Measure.

144 square inches=1 square foot
9 ,, feet=1 ,, yard
$30\frac{1}{4}$,, yards=1 ,, rod, pole, or perch
40 ,, poles=1 rood
4 roods=1 acre=4840 square yards
640 acres=1 square mile

Cubic or Solid Measure.

1728 cubic inches=1 cubic foot	log. 1728=3·237 5437
27 ,, feet =1 ,, yard	log. 27=1·431 3638

				Logarithms.
1 cubic inch of water* at 62° Fahr. weighs			252·286 grains	2·401 8981
,,	,,	,,	0·57665 oz. (av.)	$\bar{1}$·760 9150
,,	,,	,,	0·036041 lb.	$\bar{2}$·556 7951
1 cubic foot	,,	,,	996·458 oz. (av.)	2·998 4587
,,	,,	,,	62·2786 lb.	1·794 3388
,,	,,	,,	28·2491 kilograms	1·451 0046
1 cubic yard	,,	,,	0·75068 tons	$\bar{1}$·875 4546

Measures of Capacity.

4 gills =1 pint
2 pints =1 quart
4 quarts=1 gallon

Ale, Beer, and Porter Measure.

The following measures between square brackets, though in common use, are not officially recognized :—

4 gills =1 pint
2 pints =1 quart
4 quarts =1 gallon
[9 gallons =1 firkin
2 firkins =1 kilderkin= 18 gallons
2 kilderkins=1 barrel = 36 ,,
3 ,, =1 hogshead= 54 ,,
3 hogsheads=1 butt =108 ,,]

Dry Measure.

2 pints	=1 quart	4 pecks	=1 bushel
4 quarts	=1 gallon	8 bushels	=1 quarter
2 gallons	=1 peck	4 quarters	=1 chaldron

* *i.e.*, distilled water freed from air.

WEIGHTS AND MEASURES—*continued.*

II. WEIGHTS AND MEASURES OF THE METRIC SYSTEM.

Measures of Weight.

The metric standard of weight is the kilogram, which is represented by a certain iridio-platinum weight deposited with the Board of Trade.

One-thousandth part of this is the gram, which constitutes the *practical* unit of weight, the fractions and multiples of which are thus designated :—

0·1 gram	=1 decigram	10 grams	=1 dekagram
0·01 ,,	=1 centigram	100 ,,	=1 hectogram
0·001 ,,	=1 milligram	1000 ,,	=1 kilogram

Measures of Capacity.

The standard litre is the volume of a kilogram of pure water at 4° C. under standard barometric pressure.

The value of the litre in terms of the cubic centimetre has been the subject of numerous experiments. Very exact measurements made during the last few years have shown that

1 litre=1000·028 cubic centimetres (c.c., c. cm., or cm^3.).

Hence in all but the most refined experiments the volume of one cubic centimetre may be taken as one-thousandth part of that of the litre (*i.e.* one millilitre or mil*).

1 decilitre=100 c.c. | 1 centilitre=10 c.c.

Measures of Length.

The metre is represented by the length, at 0° C., of a certain iridio-platinum bar deposited with the Board of Trade. The fractions and multiples are as follows :—

0·1 metre	=1 decimetre (dm.)	10 metres	=1 dekametre
0·01 ,,	=1 centimetre (cm.)	100 ,,	=1 hectometre
0·001 ,,	=1 millimetre (mm.)	1000 ,,	=1 kilometre

0·001 mm. =1 micron (μ)=0·00004 inch (nearly).

0·000001 mm. =1 micromillimetre † ($\mu\mu$)=0·00000004 inch (nearly).

TABLES FOR THE CONVERSION OF METRIC INTO IMPERIAL MEASURES AND *vice versa.*

A. *Linear Measure.*

Metric into Imperial.		Logarithms.
1 millimetre (mm.)	= 0·0393701 inches	$\bar{2}$·595 1666
1 centimetre (cm.)	= 0·393701 ,,	$\bar{1}$·595 1666
1 decimetre (dm.)	= 3·937011 ,,	0·595 1666
1 metre (m.)	=39·370113 ,,	1·595 1666
,,	= 3·280843 feet	0·515 9855
,,	= 1·093614 yards	0·038 8642
1 kilometre (km.)	= 1093·61426 ,,	3·038 8642
,,	= 0·621372 mile	$\bar{1}$·793 3517

*** 33 cm. =13 inches within 0·008 inch in deficiency.

127 cm. =50 inches within 0·00005 inch in excess.

* For pharmaceutical purposes the terms mil (=millilitre), decimil (0·1 mil) and centimil (0·01 mil) have been legalized and are in regular use.

† The prefix *micro* always indicates a millionth part of the unit.

WEIGHTS AND MEASURES—*continued.*

Imperial into Metric.	Logarithms.
1 inch = 2·540 centimetres	0·404 8337
1 foot = 30·480 ,, ...	1·484 0150
1 yard = 0·914399 metre	$\bar{1}$·961 1357
1 mile = 1·6093 kilometres	0·206 6370

*** 1613 metres=1764 yards, within 0·008 inch in deficiency.

mm. Inch.	Metres. Feet.	Inches. mm.	Feet. Metres.
1=·03937	1= 3·2808	1= 25·4	1=0·3048
2=·07874	2= 6·5616	2= 50·8	2=0·6096
3=·11811	3= 9·8424	3= 76·2	3=0·9144
4=·15748	4=13·1232	4=101·6	4=1·2192
5=·19685	5=16·4040	5=127·0	5=1·5240
6=·23622	6=19·6848	6=152·4	6=1·8288
7=·27559	7=22·9656	7=177·8	7=2·1336
8=·31496	8=26·2464	8=203·2	8=2·4384
9=·35433	9=29·5272	9=228·6	9=2·7432

B. *Square Measure.*

Metric into Imperial.		Logarithms.
1 square decimetre (dm^2.)	= 15·500 square inches .	1·190 3317
1 square metre (m^2.) or centiare	= 10·7639 square feet . .	1·031 9697
,, ,,	= 1·1960 square yards .	0·077 7312
1 are (100 square metres)	=119·60 ,, ,, .	2·077 7312
,, ,,	= 0·024711 acres . .	$\bar{2}$·392 8908

Imperial into Metric.	
1 square inch = 6·4516 square centimetres	0·809 6674
1 square foot = 9·2903 square decimetres	0·968 0297
1 square yard = 0·836126 square metres	$\bar{1}$·922 2717
1 acre = 0·40468 hectare	$\bar{1}$·607 1117
1 square mile (640 acres) = 259·00 hectares	2·413 2998

C. *Cubic Measure and Measures of Capacity.*

Metric into Imperial, etc.		
1 cubic centimetre (c.c.)	= 0·0610 cubic inch . . .	$\bar{2}$·785 3298
,,	=16·894 minims	1·227 7325
,,	= 0·28157 fluid drachm . . .	$\bar{1}$·449 5864
,,	= 0·035196 fluid ounce . . .	$\bar{2}$·546 4933
1 litre	=61·024 cubic inches . . .	1·785 5007
,,	=35·1960 fluid ounces . . .	1·546 4933
,,	= 1·75980 pints	0·245 4633
,,	= 0·2200 gallon	$\bar{1}$·342 4227
1 hectolitre	= 2·75 bushels	0·439 3327
1 cubic metre (m^3.)	=35·3148 cubic feet . . .	1·547 9567
,,	= 1·307954 cubic yards . . .	0·116 5924

*** 25 litres=44 pints within 0·005 pint in deficiency.
5 dekalitres=11 gallons within 0·002 gallon in deficiency.

WEIGHTS AND MEASURES—*continued.*

c.c.	Cubic Inch.
1	=0·061024
2	=0·122048
3	=0·183072
4	=0·244096
5	=0·305120
6	=0·366144
7	=0·427168
8	=0·488192
9	=0·549216

Litres.	Fluid Ounces.	Pints.	Gallons.
1	= 35·1960	= 1·7598	= 0·22
2	= 70·3920	= 3·5196	= 0·44
3	=105·5880	= 5·2794	= 0·66
4	=140·7840	= 7·0392	= 0·88
5	=175·9800	= 8·7990	= 1·10
6	=211·1760	=10·5588	= 1·32
7	=246·3720	=12·3186	= 1·54
8	=281·5680	=14·0784	= 1·76
9	=316·7640	=15·8382	= 1·98

	Imperial into Metric.	Logarithms.
1 cubic inch	= 16·387 cubic centimetres	1·214 4995
1 cubic foot	= 28·317 cubic decimetres	1·452 0472
1 cubic yard	= 0·764553 cubic metre	$\bar{1}$·883 4076

1 minim	= 0·059 cubic centimetre	$\bar{2}$·770 8520
1 fluid drachm	= 3·552 cubic centimetres	0·550 4780
1 fluid ounce	= 28·4123 ,,	1·453 5064
1 pint	= 568·25 ,,	2·754 5394
1 quart	= 1·13649 litres	0·055 5656
1 gallon	= 4·5459631 litres	0·657 6260

Cubic Inches.	Cubic Centimetres.
1	= 16·387
2	= 32·774
3	= 49·161
4	= 65·548
5	= 81·935
6	= 98·322
7	=114·709
8	=131·096
9	=147·483

Fluid Ounces.	Cubic Centimetres.
1	= 28·4123
2	= 56·8246
3	= 85·2369
4	=113·6492
5	=142·0615
6	=170·4738
7	=198·8861
8	=227·2984
9	=255·7107

Pints.	Litres.
1	=0·56825
2	=1·13650
3	=1·70475
4	=2·27300
5	=2·84125
6	=3·40950
7	=3·97775
8	=4·54600
9	=5·11425

Gallons.	Litres.
1	= 4·54596
2	= 9·09192
3	=13·63788
4	=18·18384
5	=22·72980
6	=27·27576
7	=31·82172
8	=36·36768
9	=40·91364

Note.—The following measure, though not recognized officially, is much used in certain trades:—1 barn gallon = 17 pints = 9·6602 litres.

WEIGHTS AND MEASURES—*continued.*

Metric into Imperial.

		Logarithms.
1 milligram	= 0·01543 grain	$\bar{2}$·188 4324
1 centigram	= 0·15432 grain	$\bar{1}$·188 4324
1 decigram	= 1·54324 grains	0·188 4324
1 gram	= 15·43236 grains	1·188 4324
,,	= 0·564383 dram avoirdupois	$\bar{1}$·751 5739
,,	= 0·035274 ounce avoirdupois	$\bar{2}$·547 4547
,,	= 0·25721 drachm (apothecaries)	$\bar{1}$·410 2878
,,	= 0·0321507 ounce troy	$\bar{2}$·507 1905
1 kilogram	= 15432·3564 grains	4·188 4324
,,	= 35·2740 ounces avoirdupois	1·547 4547
,,	= 2·2046223 lb.	0·343 3341
,,	= 32·15074 ounces troy	1·507 1910
1 quintal (100 kilog.)	= 1·968 cwt.	0·294 0251
1 tonne (1000 kilog.)	= 0·9842 ton	$\bar{1}$·993 0334

Grams.	Grains.	Oz. (Av.).	Oz. (Troy).
1=	15·43236=	0·035274=	0·0321507
2=	30·86472=	0·070548=	0·0643014
3=	46·29708=	0·105822=	0·0964521
4=	61·72944=	0·141096=	0·1286028
5=	77·16180=	0·176370=	0·1607535
6=	92·59416=	0·211644=	0·1929042
7=	108·02652=	0·246918=	0·2250549
8=	123·45888=	0·282192=	0·2572056
9=	138·89124=	0·317466=	0·2893563

Kilograms.	Pounds.
1=	2·20462
2=	4·40924
3=	6·61386
4=	8·81848
5=	11·02310
6=	13·22772
7=	15·43234
8=	17·63696
9=	19·84158

Imperial into Metric.

		Logarithms.
1 grain	= 0·0648 gram	$\bar{2}$·811 5750
1 drachm (apoth.)	= 3·888 grams	0·589 7263
1 ounce troy	= 31·1035 grams	1·492 8093
1 dram avoirdupois	= 1·772 grams	0·248 4637
1 ounce avoirdupois	= 28·350 grams	1·452 5531
1 pound (16 oz.)	= 453·59243 grams	2·656 6658
1 stone (14 lb.)	= 6·350 kilograms	0·802 7737
1 quarter (28 lb.)	= 12·70 kilograms	1·103 8037
1 cwt. (112 lb.)	= 50·80 kilograms	1·705 8637
,,	= 0·5080 quintal	$\bar{1}$·705 8637
1 ton (20 cwt.)	= 1016·0 kilograms	3·006 8937

Grains.	Gram.
1=	0·06480
2=	0·12960
3=	0·19440
4=	0·25920
5=	0·32399
6=	0·38879
7=	0·45359
8=	0·51839
9=	0·58319

Ounces. (Av.)=	Grams.
1=	28·35
2=	56·70
3=	85·05
4=	113·40
5=	141·75
6=	170·10
7=	198·45
8=	226·80
9=	255·15

*** 44 kilograms = 97 pounds within 0·004 lb. in excess.
303 ,, = 668 ,, ,, 0·0006 lb. ,,

WEIGHTS AND MEASURES—*continued.*

Pounds to Kilograms.	Hundredweights to Kilograms.
1 = 0·45359	1 = 50·8
2 = 0·90718	2 = 101·6
3 = 1·36077	3 = 152·4
4 = 1·81436	4 = 203·2
5 = 2·26795	5 = 254·0
6 = 2·72154	6 = 304·8
7 = 3·17513	7 = 355·6
8 = 3·62872	8 = 406·4
9 = 4·08231	9 = 457·2

Ex. 1. How many c.c. are equivalent to 84 cubic inches? From the table on p. 59 8 cubic inches = 131·096 c.c. and 4 cubic inches = 65·548 c.c.

$$\therefore\ 80 = 1310{\cdot}96$$
$$4 = \quad 65{\cdot}548$$
$$\overline{1376{\cdot}508 \text{ c.c.}}$$

Ex. 2. How many grams are equivalent to 39 ounces (av.)?

$$30 = 850{\cdot}5$$
$$9 = 255{\cdot}15$$
$$\overline{1105{\cdot}65 \text{ grams.}}$$

TABLE SHOWING THE SIGNS USED IN WRITING MEDICAL PRESCRIPTIONS.

½ grain . .	½ gr.	1 drachm . .	ʒ i, or ʒ j.
1 ,, . .	gr. j, or gr. i.	1½ ,, . .	ʒ iss.
1½ ,, . .	gr. iss.	2 drachms . .	ʒ ii, or ʒ ij.
2 grains .	gr. ii, or gr. ij.	3 ,, . .	ʒ iii, or ʒ iij.
2½ ,, . .	gr. iiss.	3½ ,, . .	ʒ iiiss.
4 ,, . .	gr. iv.	7½ ,, . .	ʒ viiss.
8 ,, . .	gr. viii, or gr. viij.	½ ounce . .	℥ ss.
½ scruple .	℈ ss.	1 ,, . .	℥ i, or ℥ j.
1 ,, .	℈ i, or ℈ j.	1½ ,, . .	℥ iss.
1½ ,, .	℈ iss.	½ pint . .	Oss.
2 scruples .	℈ ii, or ℈ ij.	1 ,, . .	O.

Foreign Weights and their English Equivalents.

The Metric System is compulsory in Austria, Belgium, France, Germany, Greece, Italy, Luxemburg, the Netherlands, Portugal, Roumania, Spain, Switzerland, Turkey, and most of the South American Republics; optional in Great Britain, the United States, and Russia.

1 quintal = 100 kg. = 1·968 cwts.
1 metric ton = 1000 kg. = 0·9842 ton.
= 1·1023 American short tons (2000 lb.)

Austria-Hungary	1 pfund = 1·2346 lb.
Belgium	1 livre = 1·102 ,,
Egypt	1 cantar = 99·045 ,,
Germany	1 pfund = 500 grams.
Russia	1 pound = 0·9028 lb.
	1 pood * (40 pounds) = 36·113 lb.
Sweden	1 pound = 0·9377 lb.
Switzerland	1 zollpfund = 500 grams.
China	1 tael = 1·333 oz. av.
	1 chin = 16 tael = 1·333 lb.
Japan	1 kin (=160 mommé) = 1·3227 ,,
	1 kwan = 8·2672 lb.
	[1 koku (=100 sho) = 39·674 gallons.]

Foreign Moneys and their English Equivalents (in 1912).

		s.	d.
Austria-Hungary	1 krone (=100 heller)	0	10
China	1 silver yuan or dollar (=100 cents)	2	0
Denmark, Norway and Sweden	1 krone (=100 ore)	1	1½
Egypt	£E1 (=100 piastres)	20	8¾
France	1 franc (=100 centimes)	0	9½
Germany	1 mark (=100 pfennige)	0	11¾
Holland	1 florin (=100 cents)	1	8
India	1 rupee (=16 annas)	1	4
Italy	1 lira (=100 centesimi)	0	[illegible]
Japan	1 yen (=100 sen)	2	
Mexico	1 peso (=100 centavos)	2	0½
Russia	1 rouble (100 kopecks)	2	1⅛
Spain	1 peseta (=100 centimos)	0	9½
Turkey	£T1 (=100 piastres)	18	0
United States	1 dollar (=100 cents)	4	1¼

* 63 poods = 2275 lb. = 1 English ton nearly.

DENSITIES OF COMMONLY OCCURRING SUBSTANCES (AT 15° C.)

Agate	2·6	Graphite	2·2
Aluminium	2·7	Gutta-percha	0·97
Aluminium bronze	8	Gypsum	2·3
Amber	1·1	Heavy spar	4·5
Amphibole	2·9–3·4	Haematite	5
Anhydrite	2·98	Iceland Spar	2·7
Anthracite	1·27–1·75	India-rubber	0·99
Antimony	6·7	Iodine	5
Apatite	3·3	Iron (cast)	7·2–7·5
Arragonite	3	,, (wrought)	7·8
Arsenic	5·7	Ivory	1·92
Bamboo	0·4	Lead	11·4
Basalt	2·8	Lime	3·2
Beech-wood	0·69–·8	Lithium	0·59
Beeswax	0·96	Magnesium	1·74
Bismuth	9·8	Mahogany	·56–·85
Bitumen	0·8–1·2	Marble	2·7
Box-wood	0·96	Mercury	13·6
Bone	1·8–2	Mica	2·7–3·1
Brass	8	Milk (cows')	1·03
Brick	2·1	Nickel	8·8
Bromine	3	Oak (English)	0·93
Bronze coinage	8·66	Phosphorus (yellow)	1·84
Cadmium	8·6	,, (red)	2·2
Calamine	3·4	Pine-wood	0·56
Calc-spar	2·7	Platinum	21·5
Chalk (mean)	2·3	Potassium	0·88
Charcoal	1·5	Pyrites (iron)	5
Chloroform	1·5	Pyrolusite	4·9
Chrome alum	1·83	Pumice-stone	2·2–2·5
Cinnabar	8·1	Sand (dry)	1·4
Coal	1·25–1·33	Sea-water	1·026
Cobalt	8·9	Selenite	2·3
Copper	8·9	Serpentine	2·6
Cork	0·24	Silver	10·5
Diamond	3·5	,, coinage (British)	10·35–10·38*
Dolomite	2·9	Slate	2·1–2·8
Ebony	1·2	Sodium	0·97
Elm (dry)	0·59	Spermaceti	0·94
Emery	4	Strontianite	3·6
Felspar	2·4–2·6	Sugar (cane)	1·6
Fir (Riga)—dry	0·75	Sulphur	2·07
Fluor-spar	3·2	Talc	2·5
Galena	7·6	Teak (Indian)	0·66
Glass (crown)	2·5	Tin	7·24–7·3
,, (flint)	2·9–3·25	Tinstone	6·9
,, (Bohemian)	2·4	Turpentine	0·87
Glycerine	1·26	Willow-wood	0·4
Gold	19·3	Witherite	4·3
,, (18 carat)	14·88	Wool	1·6
,, coinage (British)	17·48*	Zinc	6·9–7·2
Granite	2·7	Zinc blende	4·16

* These values were kindly supplied to the author by Dr. T. K. Rose, Chemist to

Table of Freezing Mixtures.

A mixture of (parts by weight).	Temperature produced.
Snow or broken ice, 2; common salt, 1	−18° C.
,, ,, 3; calcium chloride (cryst.) 4	−48° C.
Sodium sulphate (cryst.), 8; muriatic acid, 5	−18° C.
,, phosphate (cryst.), 9; nitric acid, 4	−29° C.
Ammonium nitrate, 1; water, 1	−16° C.
Ammonium chloride, 5; saltpetre, 5; sodium sulphate, 8; water, 16	−20° C.

Note.—The solids used should be finely powdered.

Table for the Conversion of Percentage into cwts., qrs., and lb. per ton, and into qrs. and lb. per cwt.

Per cent.	Per ton.			Per cwt.		Per cent.	Per ton.			Per cwt.	
	cwt.	qrs.	lb.	qrs.	lb.		cwt.	qrs.	lb.	qrs.	lb.
1	..	..	22·4	..	1·12	29	5	3	5·6	1	4·48
2	..	1	16·8	..	2·24	30	6	..	..	1	5·60
3	..	2	11·2	..	3·36	31	6	..	22·4	1	6·72
4	..	3	5·6	..	4·48	32	6	1	16·8	1	7·84
5	1	..	..	..	5·60	33	6	2	11·2	1	8·96
6	1	..	22·4	..	6·72	34	6	3	5·6	1	10·08
7	1	1	16·8	..	7·84	35	7	..	..	1	11·20
8	1	2	11·2	..	8·96	36	7	..	22·4	1	12·32
9	1	3	5·6	..	10·08	37	7	1	16·8	1	13·44
10	2	..	..	..	11·20	38	7	2	11·2	1	14·56
11	2	..	22·4	..	12·32	39	7	3	5·6	1	15·68
12	2	1	16·8	..	13·44	40	8	..	..	1	16·8
13	2	2	11·2	..	14·56	41	8	..	22·4	1	17·92
14	2	3	5·6	..	15·68	42	8	1	16·8	1	19·04
15	3	..	..	..	16·8	43	8	2	11·2	1	20·16
16	3	..	22·4	..	17·92	44	8	3	5·6	1	21·28
17	3	1	16·8	..	19·04	45	9	..	..	1	22·40
18	3	2	11·2	..	20·16	46	9	..	22·4	1	23·52
19	3	3	5·6	..	21·28	47	9	1	16·8	1	24·64
20	4	..	..	..	22·40	48	9	2	11·2	1	25·76
21	4	..	22·4	..	23·52	49	9	3	5·6	1	26·88
22	4	1	16·8	..	24·64	50	10	..	..	2	..
23	4	2	11·2	..	25·76	51	10	..	22·4	2	1·12
24	4	3	5·6	..	26·88	52	10	1	16·8	2	2·24
25	5	..	..	1	..	53	10	2	11·2	2	3·36
26	5	..	22·4	1	1·12	54	10	3	5·6	2	4·48
27	5	1	16·8	1	2·24	55	11	..	..	2	5·60
28	5	2	11·2	1	3·36	56	11	..	22·4	2	6·72

Per cent.	lb. per cwt.	lb. per ton
·1	·112	2·24
·2	·224	4·48
·3	·336	6·72
·4	·448	8·96
·5	·56	11·2
·6	·672	13·44
·7	·784	15·68
·8	·896	17·92
·9	1·008	20·16

TABLE FOR THE CONVERSION OF PERCENTAGE INTO CWTS., QRS., LB. PER TON, AND INTO QRS. AND LB. PER CWT.—*continued*.

Per cent.	Per ton.			Per cwt.		Per cent.	Per ton.			Per c…	
	cwt.	qrs.	lb.	qrs.	lb.		cwt.	qrs.	lb.	qrs.	
57	11	1	16·8	2	7·84	79	15	3	5·6	3	
58	11	2	11·2	2	8·96	80	16	..	..	3	
59	11	3	5·6	2	10·08	81	16	..	22·4	3	
60	12	..	..	2	11·20	82	16	1	16·8	3	
61	12	..	22·4	2	12·32	83	16	2	11·2	3	
62	12	1	16·8	2	13·44	84	16	3	5·6	3	1
63	12	2	11·2	2	14·56	85	17	..	..	3	1
64	12	3	5·6	2	15·68	86	17	..	22·4	3	1
65	13	..	..	2	16·8	87	17	1	16·8	3	1
66	13	..	22·4	2	17·92	88	17	2	11·2	3	1
67	13	1	16·8	2	19·04	89	17	3	5·6	3	1
68	13	2	11·2	2	20·16	90	18	..	..	3	1
69	13	3	5·6	2	21·28	91	18	..	22·4	3	1
70	14	..	..	2	22·40	92	18	1	16·8	3	1
71	14	..	22·4	2	23·52	93	18	2	11·2	3	2
72	14	1	16·8	2	24·64	94	18	3	5·6	3	2
73	14	2	11·2	2	25·76	95	19	..	..	3	2
74	14	3	5·6	2	26·88	96	19	..	22·4	3	2
75	15	..	..	3	..	97	19	1	16·8	3	2
76	15	..	22·4	3	1·12	98	19	2	11·2	3	2
77	15	1	16·8	3	2·24	99	19	3	5·6	3	2
78	15	2	11·2	3	3·36	100	20	..	..	4	

Per cent.	·1	·2	·3	·4	·5	·6	·7	·8	
lb. per cwt.	·112	·224	·336	·448	·56	·672	·784	·896	
lb. per ton	2·24	4·48	6·72	8·96	11·2	13·44	15·68	17·92	2

TABLE FOR THE CONVERSION OF DRAMS PER LB. INTO PERCENTAGE AND INTO LB. PER TON.

Drams per lb. (av.)	Per cent.	Lb. per ton (2240 lb.).	Drams per lb. (av.)	Per cent.	Lb. pe… (2240 …
¼	0·097656 (or 0·1 nearly)	2·187494	3¾	1·465	32·
½	·195	4·37	4	1·562	35·
¾	·293	6·56	4¼	1·660	37·
1	·390625 *	8·75 †	4½	1·758	39·
1¼	·488	10·94	4¾	1·855	41·
1½	·586	13·12	5	1·953	43·
1¾	·683	15·31	10	3·906	87·
2	·781	17·50	15	5·859	131·
2¼	·879	19·68	20	7·812	175·
2½	·976	21·87	25	9·765	218·
2¾	1·074	24·06	30	11·719	262·
3	1·172	26·25	35	13·672	306·
3¼	1·269	28·43	40	15·625	350·
3½	1·367	30·62	45	17·578	393·
			50	19·531	437·

* Log. $\bar{1}$·59176.

† Log. 0·94200.

The Barometer.

I. *Inches into Millimetres.*

Inches.	Milli-metres.	Inches.	Milli-metres.	Inches.	Milli-metres.	Inches.	Milli-metres.
27·5	698·49	28·4	721·35	29·3	744·21	30·2	767·07
·6	701·03	·5	723·89	·4	746·75	·3	769·61
·7	703·57	·6	726·43	·5	749·29	·4	772·15
·8	706·11	·7	728·97	·6	751·83	·5	774·69
·9	708·65	·8	731·51	·7	754·37	·6	777·23
28·0	711·19	·9	734·05	·8	756·91	·7	779·77
·1	713·73	29·0	736·59	·9	759·45	·8	782·31
·2	716·27	·1	739·13	30·0	761·99	·9	784·85
·3	718·81	·2	741·67	·1	764·53		

Inches,	·01	·02	·03	·04	·05	·06	·07	·08	·09
Millimetres,	·25	·51	·76	1·02	1·27	1·52	1·78	2·03	2·29

II. *Millimetres into Inches.*

Mm.	Inches.	Mm.	Inches.	Mm.	Inches.	Mm.	Inches.	Mm.	Inches.
700	27·56	718	28·27	735	28·94	752	29·61	769	30·28
701	·60	719	·31	736	·98	753	·65	770	·32
702	·64	720	·35	737	29·02	754	·69	771	·36
703	·68	721	·39	738	·06	755	·73	772	·39
704	·72	722	·43	739	·10	756	·76	773	·43
705	·76	723	·47	740	·13	757	·80	774	·47
706	·80	724	·50	741	·17	758	·84	775	·51
707	·84	725	·54	742	·21	759	·88	776	·55
708	·88	726	·58	743	·25	760	·92	777	·59
709	·91	727	·62	744	·29	761	·96	778	·63
710	·95	728	·66	745	·33	762	30·00	779	·67
711	·99	729	·70	746	·37	763	·04	780	·71
712	28·03	730	·74	747	·41	764	·08	781	·75
713	·07	731	·78	748	·45	765	·12	782	·79
714	·11	732	·82	749	·49	766	·16	783	·83
715	·15	733	·86	750	·53	767	·20	784	·87
716	·19	734	·90	751	·57	768	·24	785	·91
717	·23								

Table for Correction of Volumes of Gases for Temperature, giving the Divisor for the Formula.

$$V^1 = \frac{V \times B}{760 \times (1 + \delta t)} \quad \delta = \cdot 003665$$

t	$760 \times (1+\delta t)$.	Log. $[760 \times (1+\delta t)]$.	t	$760 \times (1+\delta t)$.	Log. $[760 \times (1+\delta t)]$.
° C.			° C.		
0·0	760·0000	2·8808136	4·0	771·1416	2·8871341
·1	760·2785	9727	·1	771·4201	2909
·2	760·5571	2·8811318	·2	771·6987	4477
·3	760·8356	2908	·3	771·9772	6045
·4	761·1142	4498	·4	772·2558	7612
0·5	761·3927	6087	4·5	772·5343	9178
·6	761·6712	7675	·6	772·8128	2·8880743
·7	761·9498	9263	·7	773·0914	2308
·8	762·2283	2·8820850	·8	773·3699	3872
·9	762·5069	2437	·9	773·6485	5436
1·0	762·7854	2·8824024	5·0	773·9270	2·8887000
·1	763·0639	5610	·1	774·2055	8563
·2	763·3425	7195	·2	774·4841	2·8890125
·3	763·6210	8779	·3	774·7626	1687
·4	763·8996	2·8830363	·4	775·0412	3248
1·5	764·1781	1946	5·5	775·3197	4808
·6	764·4566	3528	·6	775·5982	6368
·7	764·7352	5111	·7	775·8768	7927
·8	765·0137	6692	·8	776·1553	9486
·9	765·2923	8273	·9	776·4339	2·8901044
2·0	765·5708	2·8839854	6·0	776·7124	2·8902602
·1	765·8493	2·8841434	·1	776·9909	4159
·2	766·1279	3013	·2	777·2695	5716
·3	766·4064	4591	·3	777·5480	7272
·4	766·6850	6169	·4	777·8266	8828
2·5	766·9635	7747	6·5	778·1051	2·8910383
·6	767·2420	2·8849324	·6	778·3836	1938
·7	767·5206	2·8850901	·7	778·6622	3492
·8	767·7991	2477	·8	778·9407	5045
·9	768·0777	4052	·9	779·2193	6597
3·0	768·3562	2·8855626	7·0	779·4978	2·8918149
·1	768·6347	7199	·1	779·7763	9701
·2	768·9133	8772	·2	780·0549	2·8921252
·3	769·1918	2·8860345	·3	780·3334	2802
·4	769·4704	1918	·4	780·6120	4352
3·5	769·7489	3490	7·5	780·8905	5901
·6	770·0274	5062	·6	781·1690	7450
·7	770·3060	6633	·7	781·4476	8998
·8	770·5845	8203	·8	781·7261	2·8930546
·9	770·8631	9772	·9	782·0047	2093

TABLE FOR CORRECTION OF VOLUMES OF GASES—*continued.*

t	$760 \times (1+\delta t)$.	Log. $[760 \times (1+\delta t)]$.	t	$760 \times (1+\delta t)$.	Log. $[760 \times (1+\delta t)]$.
° C.			° C.		
8·0	782·2832	2·8933640	12·5	794·8175	2·9002674
·1	782·5617	5186	·6	795·0960	4196
·2	782·8403	6732	·7	795·3746	5717
·3	783·1188	8277	·8	795·6531	7238
·4	783·3974	9821	·9	795·9317	8758
8·5	783·6959	2·8941365	13·0	796·2102	2·9010277
·6	783·9544	2908	·1	796·4887	1796
·7	784·2330	4451	·2	796·7673	3315
·8	784·5115	5993	·3	797·0458	4833
·9	784·7901	7535	·4	797·3244	6350
9·0	785·0686	2·8949076	13·5	797·6029	7867
·1	785·3471	2·8950617	·6	797·8814	9384
·2	785·6257	2157	·7	798·1600	2·9020900
·3	785·9042	3697	·8	798·4385	2415
·4	786·1828	5236	·9	798·7171	3930
9·5	786·4613	6774	14·0	798·9956	2·9025444
·6	786·7398	8311	·1	799·2741	6957
·7	787·0184	9848	·2	799·5527	8470
·8	787·2969	2·8961385	·3	799·8312	9983
·9	787·5755	2921	·4	800·1098	2·9031495
10·0	787·8540	2·8964457	14·5	800·3883	2·9033007
·1	788·1325	5993	·6	800·6668	4518
·2	788·4111	7528	·7	800·9454	6029
·3	788·6896	9062	·8	801·2239	7539
·4	788·9682	2·8970595	·9	801·5025	9049
10·5	789·2467	2128	15·0	801·7810	2·9040558
·6	789·5252	3660	·1	802·0595	2066
·7	789·8038	5192	·2	802·3381	3574
·8	790·0823	6723	·3	802·6166	5081
·9	790·3609	8254	·4	802·8952	6588
11·0	790·6394	2·8979784	15·5	803·1737	8095
·1	790·9179	2·8981314	·6	803·4522	9601
·2	791·1965	2843	·7	803·7308	2·9051106
·3	791·4750	4372	·8	804·0093	2611
·4	791·7536	2·8985900	·9	804·2879	4115
11·5	792·0321	7428	16·0	804·5664	2·9055619
·6	792·3106	8955	·1	804·8449	7122
·7	792·5892	2·8990482	·2	805·1235	8625
·8	792·8677	2008	·3	805·4020	2·9060127
·9	793·1463	3533	·4	805·6806	1628
12·0	793·4248	2·8995058	16·5	805·9591	2·9063129
·1	793·7033	6582	·6	806·2376	4630
·2	793·9819	8106	·7	806·5162	6130
·3	794·2604	9629	·8	806·7947	7630
·4	794·5390	2·9001152	·9	807·0733	9129

TABLE FOR CORRECTION OF VOLUMES OF GASES—*continued.*

t	760× (1+δt).	Log. [760× (1+δt)].	t	760× (1+δt).	Log. [760× (1+δt)].
° C.			° C.		
17·0	807·3518	2·9070628	21·5	819·8861	2·9137535
·1	807·6303	2126	·6	820·1646	9010
·2	807·9089	3624	·7	820·4432	2·9140485
·3	808·1874	5121	·8	820·7217	1960
·4	808·4660	6618	·9	821·0003	3434
17·5	808·7445	8114	22·0	821·2788	2·9144907
·6	809·0230	2·9079609	·1	821·5573	6380
·7	809·3016	2·9081104	·2	821·8359	7852
·8	809·5801	2598	·3	822·1144	9323
·9	809·8587	4092	·4	822·3930	2·9150794
18·0	810·1372	2·9085586	22·5	822·6715	2265
·1	810·4175	7079	·6	822·9500	3735
·2	810·6943	8571	·7	823·2286	5205
·3	810·9728	2·9090063	·8	823·5071	6674
·4	811·2514	1554	·9	823·7857	8143
18·5	811·5299	3045	23·0	824·0642	2·9159611
·6	811·8084	4535	·1	824·3427	2·9161079
·7	812·0870	6025	·2	824·6213	2546
·8	812·3655	7515	·3	824·8998	4013
·9	812·6441	9004	·4	825·1784	5479
19·0	812·9226	2·9100492	23·5	825·4569	6945
·1	813·2011	1980	·6	825·7354	8410
·2	813·4797	3467	·7	826·0140	9875
·3	813·7582	4954	·8	826·2925	2·9171339
·4	814·0368	6440	·9	826·5711	2802
19·5	814·3153	7926	24·0	826·8496	2·9174265
·6	814·5938	9411	·1	827·1281	5728
·7	814·8724	2·9110896	·2	827·4067	7190
·8	815·1500	2380	·3	827·6852	8652
·9	815·4925	3864	·4	827·9638	2·9180114
20·0	815·7080	2·9115347	24·5	828·2423	1575
·1	815·9865	6830	·6	828·5208	3035
·2	816·2651	8312	·7	828·7994	4495
·3	816·5436	9794	·8	829·0779	5954
·4	816·8222	2·9121275	·9	829·3565	7412
20·5	817·1007	2756	25·0	829·6350	2·9188870
·6	817·3792	4236	·1	829·9135	2·9190328
·7	817·6578	2·9125716	·2	830·1921	1785
·8	817·9363	7195	·3	830·4706	3242
·9	818·2149	8674	·4	830·7492	4699
21·0	818·4934	2·9130152	25·5	831·0277	2·9196155
·1	818·7719	1630	·6	831·3062	7610
·2	819·0505	3107	·7	831·5848	9065
·3	819·3290	4583	·8	831·8633	2·9200520
·4	819·6076	6059	·9	831·1419	1974

TABLE FOR CORRECTION OF VOLUMES OF GASES—*continued.*

t	$760\times(1+\delta t)$.	Log. $[760\times(1+\delta t)]$.	t	$760\times(1+\delta t)$.	Log. $[760\times(1+\delta t)]$.
° C.			° C.		
26·0	832·4204	2·9203427	28·1	838·2697	2·9233838
·1	832·6989	4880	·2	838·5483	5281
·2	832·9775	6333	·3	838·8268	6723
·3	833·2560	7785	·4	839·1054	8165
·4	833·5346	9237	28·5	839·3839	2·9239606
26·5	833·8131	2·9210688	·6	839·6624	2·9241047
·6	834·0916	2139	·7	839·9410	2488
·7	834·3702	3589	·8	840·2195	3928
·8	834·6487	5038	·9	840·4981	5368
·9	834·9273	6487	29·0	840·7766	2·9246807
27·0	835·2058	2·9217936	·1	841·0551	8246
·1	835·4843	9384	·2	841·3337	9684
·2	835·7629	2·9220832	·3	841·6122	2·9251122
·3	836·0414	2279	·4	841·8908	2559
·4	836·3200	3725	29·5	842·1693	3995
27·5	836·5985	5171	·6	842·4478	5431
·6	836·8770	6617	·7	842·7264	6866
·7	837·1556	8062	·8	843·0049	8301
·8	837·4341	9507	·9	843·2835	9736
·9	837·7127	2·9230951	30·0	843·5620	2·9261171
28·0	837·9912	2·9232395			

TENSION OF MERCURY VAPOUR (Ramsay and Young).

° C.	mm.	° C.	mm.	° C.	mm.
50	0·015	190	12·14	290	193·98
100	0·27	200	17·02	300	246·70
110	0·45	210	23·48	310	304·79
120	0·72	220	31·96	320	373·58
130	1·14	230	42·92	330	454·28
140	1·76	240	56·92	340	546·72
150	2·68	250	74·59	350	658·52
160	4·01	260	96·66	360	785·11
170	5·90	270	123·91		
180	8·54	280	157·38		

Volume and Density of Water at different Temperatures.*

Temp.	Sp. gr. of Water (at 0°=1).	Vol. of Water (at 0°=1).	Sp. gr. of Water (at 4°=1).	Vol. of Water (at 4°=1).
0°	1·000000	1·000000	·999871	1·000129
1	1·000057	0·999943	·999928	1·000072
2	1·000098	·999902	·999969	1·000031
3	1·000120	·999880	·999991	1·000009
4	1·000129	·999871	1·000000	1·000000
5	1·000119	·999881	0·999990	1·000010
6	1·000099	·999901	·999970	1·000030
7	1·000062	·999938	·999933	1·000067
8	1·000015	·999985	·999886	1·000114
9	0·999953	1·000047	·999824	1·000176
10	·999876	1·000124	·999747	1·000253
11	·999784	1·000216	·999655	1·000345
12	·999678	1·000322	·999549	1·000451
13	·999559	1·000441	·999430	1·000570
14	·999429	1·000572	·999299	1·000701
15	·999289	1·000712	·999160	1·000841
16	·999131	1·000870	·999002	1·000999
17	·998970	1·001031	·998841	1·001160
18	·998782	1·001219	·998654	1·001348
19	·998588	1·001413	·998460	1·001542
20	·998388	1·001615	·998259	1·001744
21	·998176	1·001828	·998047	1·001957
22	·997958	1·002049	·997826	1·002177
23	·997730	1·002276	·997601	1·002405
24	·997495	1·002511	·997367	1·002641
25	·997249	1·002759	·997120	1·002888
26	·996994	1·003014	·996866	1·003144
27	·996732	1·003278	·996603	1·003408
28	·996460	1·003553	·996331	1·003682
29	·996179	1·003835	·996051	1·003965
30	·995894	1·004123	·995765	1·004253
35	0·99431	1·00572	0·99418	1·00598
40	0·99248	1·00757	0·99235	1·00778
45	0·99050	1·00958	0·99037	1·00974
50	0·98832	1·01182	0·98819	1·01201
55	0·98594	1·01426	0·98581	1·01442
60	0·98350	1·01678	0·98338	1·01697
65	0·98086	1·01951	0·98074	1·01971
70	0·97807	1·02243	0·97794	1·02260
75	0·97511	1·02558	0·97498	1·02569
80	0·97206	1·02874	0·97194	1·02890
85	0·96892	1·03207	0·96879	1·03224
90	0·96568	1·03554	0·96556	1·03574
95	0·96231	1·03918	0·96219	1·03938
100	0·95879	1·04299	0·95866	1·04315

This table may be utilized to reduce a sp. gr. taken with reference to water at one temperature to water at 4° C. Thus, let S_{15} be the sp. gr. of a substance referred to water at 15° C. as unity, then the sp. gr. (S_4) referred to water at 4° as unity will be $S_4 = S_{15} \times \cdot 99916 = S_{15}(1 - \cdot 00084)$.

* Rosetti.

BAUMÉ'S HYDROMETER.—*Table for Liquids heavier than Water.**

°B.	°Tw.	Sp. gr.	°B.	°Tw.	Sp. gr.	°B.	°Tw.	Sp. gr.
1	1·4	1·007	23	33	1·190	45	90·6	1·453
2	2·8	1·014	24	40	1·200	46	93·6	1·468
3	4·4	1·022	25	42	1·210	47	96·6	1·483
4	5·8	1·029	26	44	1·220	48	99·6	1·498
5	7·4	1·037	27	46·2	1·231	49	103	1·515
6	9	1·045	28	48·2	1·241	50	106	1·530
7	10·2	1·052	29	50·4	1·252	51	109·2	1·546
8	12	1·060	30	52·6	1·263	52	112·6	1·563
9	13·4	1·067	31	54·8	1·274	53	116	1·580
10	15	1·075	32	57	1·285	54	119·4	1·597
11	16·6	1·083	33	59·4	1·297	55	123	1·615
12	18·2	1·091	34	61·6	1·308	56	127	1·635
13	20	1·100	35	64	1·320	57	130·4	1·652
14	21·6	1·108	36	66·4	1·332	58	134·2	1·671
15	23·2	1·116	37	69	1·345	59	138·2	1·691
16	25	1·125	38	71·4	1·357	60	142	1·710
17	26·8	1·134	39	74	1·370	61	146·4	1·732
18	28·4	1·142	40	76·6	1·383	62	150·6	1·753
19	30·4	1·152	41	79·4	1·397	63	155	1·775
20	32·4	1·162	42	82	1·410	64	159	1·795
21	34·2	1·171	43	84·8	1·424	65	164	1·820
22	36	1·180	44	87·6	1·438	66	168·4	1·842

* This is the Baumé's hydrometer mostly used on the Continent of Europe; but other scales are in use there as well, and quite another scale for Baumé's hydrometer is used in America (Lunge & Hurter, *Alkali Makers' Handbook*).

Table for Liquids lighter than Water.

°B.	Sp. gr.	°B.	Sp. gr.	°B.	Sp. gr.
10	1·000	27	0·896	44	0·811
11	0·993	28	0·890	45	0·807
12	0·986	29	0·885	46	0·802
13	0·980	30	0·880	47	0·798
14	0·973	31	0·874	48	0·794
15	0·967	32	0·869	49	0·789
16	0·960	33	0·864	50	0·785
17	0·954	34	0·859	51	0·781
18	0·948	35	0·854	52	0·777
19	0·942	36	0·849	53	0·773
20	0·936	37	0·844	54	0·768
21	0·930	38	0·839	55	0·764
22	0·924	39	0·834	56	0·760
23	0·918	40	0·830	57	0·757
24	0·913	41	0·825	58	0·753
25	0·907	42	0·820	59	0·749
26	0·901	43	0·816	60	0·745

Twaddell's Hydrometer.—To convert degrees Twaddell into specific gravity (water = 1000): multiply the number by 5, and add 1000 to the product.

To reduce specific gravity (water = 1000) to Twaddell: deduct 1000, and divide the remainder by 5

TABLE SHOWING THE STRENGTH OF HYDROCHLORIC ACID OF DIFFERENT DENSITIES. (Lunge and Marchlewski.*)

Sp. gr. at 15° C./4°.	HCl per cent.	Grams HCl per litre.	Sp. gr. at 15° C./4°.	HCl per cent.	Grams HCl per litre.	Sp. gr. at 15° C./4°.	HCl per cent.	Grams HCl per litre.
1·005	1·15	12	1·075	15·16	163	1·140	27·66	315
1·010	2·14	22	1·080	16·15	174	1·145	28·61	328
1·015	3·12	32	1·085	17·13	186	1·150	29·57	340
1·020	4·13	42	1·090	18·11	197	1·155	30·55	353
1·025	5·15	53	1·095	19·06	209	1·160	31·52	366
1·030	6·15	64	1·100	20·01	220	1·165	32·49	379
1·035	7·15	74	1·105	20·97	232	1·170	33·46	392
1·040	8·16	85	1·110	21·92	243	1·175	34·42	404
1·045	9·16	96	1·115	22·86	255	1·180	35·39	418
1·050	10·17	107	1·120	23·82	267	1·185	36·31	430
1·055	11·18	118	1·125	24·78	278	1·190	37·23	443
1·060	12·19	129	1·130	25·75	291	1·195	38·16	456
1·065	13·19	141	1·135	26·70	303	1·200	39·11	469
1·070	14·17	152						

* *Alkali Makers' Handbook* (Lunge and Hurter), p. 120.

TABLE SHOWING THE STRENGTHS OF NITRIC ACID OF DIFFERENT DENSITIES. (Lunge and Rey.*)

Sp. gr. at 15°/4°.	HNO_3 per cent.	Sp. gr. at 15°/4°.	HNO_3 per cent.	Sp. gr. at 15°/4°.	HNO_3 per cent.
1·020	3·70	1·220	35·28	1·420	69·80
1·030	5·50	1·230	36·78	1·430	72·17
1·040	7·26	1·240	38·29	1·440	74·68
1·050	8·99	1·250	39·82	1·450	77·28
1·060	10·68	1·260	41·34	1·460	79·98
1·070	12·33	1·270	42·87	1·470	82·90
1·080	13·95	1·280	44·41	1·480	86·05
1·090	15·53	1·290	45·95	1·490	89·60
1·100	17·11	1·300	47·49	1·500	94·09
1·110	18·67	1·310	49·07	1·502	95·08
1·120	20·23	1·320	50·71	1·504	96·00
1·130	21·77	1·330	52·37	1·506	96·76
1·140	23·31	1·340	54·07	1·508	97·50
1·150	24·84	1·350	55·79	1·510	98·10
1·160	26·36	1·360	57·57	1·512	98·53
1·170	27·88	1·370	59·39	1·514	98·90
1·180	29·38	1·380	61·27	1·516	99·21
1·190	30·88	1·390	63·23	1·518	99·46
1·200	32·36	1·400	65·30	1·520	99·67
1·210	33·82	1·410	67·50		

Note.—To get N_2O_5 subtract one-seventh from the percentage of nitric acid Thus, 1·450 sp. gr. = 77·28 − 11·04 = 66·24% N_2O_5.

* From Lunge's *Sulphuric Acid and Alkali*, Vol. I., third edition, 1903, pp. 99–101. The figures refer to *chemically pure* nitric acid; commercial acid, containing nitrous acid, etc., contains less real HNO_3 at the same density.

*** Veley and Manley have recently published (see *Jour. Soc. Chem. Ind.*, 1903 pp. 1227–1229) a table of densities of nitric acid from 1·385 to 1·521, the results of which agree closely with those tabulated above.

Corrections for 1° C. (Add when above 15°, subtract when below 15° C.).

Sp. gr.	Correction.	Sp. gr.	Correction.
1·020–1·040	0·0002	1·281–1·310	0·0010
1·041–1·070	0·0003	1·311–1·350	0·0011
1·071–1·100	0·0004	1·351–1·365	0·0012
1·101–1·130	0·0005	1·366–1·400	0·0013
1·131–1·160	0·0006	1·401–1·435	0·0014
1·161–1·200	0·0007	1·436–1·490	0·0015
1·201–1·245	0·0008	1·491–1·500	0·0016
1·246–1·280	0·0009	1·501–1·520	0·0017

Table Showing the Strength of Sulphuric Acid of Different Densities. (Lunge, Isler and Naef.*)

Sp. gr. at 15°/4° C.	SO_3 per cent.	H_2SO_4 per cent.	Grams H_2SO_4 per litre.	Sp. gr. at 15°/4° C.	SO_3 per cent.	H_2SO_4 per cent.	Grams H_2SO_4 per litre.
1·010	1·28	1·57	16	1·340	35·71	43·74	586
1·020	2·47	3·03	31	1·350	36·58	44·82	605
1·030	3·67	4·49	46	1·360	37·45	45·88	624
1·040	4·87	5·96	62	1·370	38·32	46·94	643
1·050	6·02	7·37	77	1·380	39·18	48·00	662
1·060	7·16	8·77	93	1·390	40·05	49·06	682
1·070	8·32	10·19	109	1·400	40·91	50·11	702
1·080	9·47	11·60	125	1·410	41·76	51·15	721
1·090	10·60	12·99	142	1·420	42·57	52·15	740
1·100	11·71	14·35	158	1·430	43·36	53·11	759
1·110	12·82	15·71	175	1·440	44·14	54·07	779
1·120	13·89	17·01	191	1·450	44·92	55·03	798
1·130	14·95	18·31	207	1·460	45·69	55·97	817
1·140	16·01	19·61	223	1·470	46·45	56·90	837
1·150	17·07	20·91	239	1·480	47·21	57·83	856
1·160	18·11	22·19	257	1·490	47·95	58·74	876
1·170	19·16	23·47	275	1·500	48·73	59·70	896
1·180	20·21	24·76	292	1·510	49·51	60·65	916
1·190	21·26	26·04	310	1·520	50·28	61·59	936
1·200	22·30	27·32	328	1·530	51·04	62·53	957
1·210	23·33	28·58	346	1·540	51·78	63·43	977
1·220	24·36	29·84	364	1·550	52·46	64·26	996
1·230	25·39	31·11	382	1·560	53·12	65·08	1015
1·240	26·35	32·28	400	1·570	53·80	65·90	1035
1·250	27·29	33·43	418	1·580	54·46	66·71	1054
1·260	28·22	34·57	435	1·590	55·18	67·59	1075
1·270	29·15	35·71	454	1·600	55·93	68·51	1096
1·280	30·10	36·87	472	1·610	56·68	69·43	1118
1·290	31·04	38·03	490	1·620	57·40	70·32	1139
1·300	31·99	39·19	510	1·630	58·09	71·16	1160
1·310	32·94	40·35	529	1·640	58·77	71·99	1180
1·320	33·88	41·50	548	1·650	59·45	72·82	1202
1·330	34·80	42·66	567	1·660	60·11	73·64	1222

* Lunge's *Sulphuric Acid and Alkali*, Vol. I., third edition, 1903, pp. 130–135.

TABLE SHOWING THE STRENGTH OF SULPHURIC ACID OF DIFFERENT DENSITIES—*continued*.

Sp. gr. at 15°/4° C.	SO_3 per cent.	H_2SO_4 per cent.	Grams H_2SO_4 per litre.	Sp. gr. at 15°/4° C.	SO_3 per cent.	H_2SO_4 per cent.	Grams H_2SO_4 per litre.
1·670	60·82	74·51	1244	1·790	69·96	85·70	1534
1·680	61·57	75·42	1267	1·795	70·45	86·30	1549
1·690	62·29	76·30	1289	1·800	70·94	86·90	1564
1·700	63·00	77·17	1312	1·805	71·50	87·60	1581
1·710	63·70	78·04	1334	1·810	72·08	88·30	1598
1·720	64·43	78·92	1357	1·815	72·69	89·05	1621
1·730	65·14	79 80	1381	1·820	73·51	90·05	1639
1·740	65·86	80·68	1404	1·825	74·29	91·00	1661
1·750	66·58	81·56	1427	1·830	75·19	92·10	1685
1·760	67·30	82·44	1451	1·835	76·27	93·43	1713
1·765	67·65	82·88	1463	1·840	78·04	95·60	1759
1·770	68·02	83·32	1475	1·840	80·98	99·20	1825
1·775	68·49	83·90	1489	1·841	79·19	97·00	1786
1·780	68·98	84·50	1504	1·841	80·16	98·20	1808
1·785	69·47	85·10	1519	1·8385	81·59	99·95	1838

Note.—The maximum density does not coincide with the greatest strength, that is, pure monohydrated sulphuric acid, H_2SO_4. The maximum density is at about 98·5 per cent., and from this point the densities decline to 100 per cent. H_2SO_4.

CORRECTION FOR 1° C. (ADD WHEN ABOVE 15°, SUBTRACT WHEN BELOW 15° C.).

Sp. gr.	Correction.
1·170 (or less)	0·0006
1·170–1·450	0·0007
1·450–1·580	0·0008
1·580–1·750	0·0009
1·750–1·840	0·0010

SPECIFIC GRAVITIES OF AQUEOUS AMMONIA.
(Lunge and Wiernik.)

Specific gravity at 15° C.	NH_3 per cent.	1 litre at 15° C. contains grams NH_3.	Specific gravity at 15° C.	NH_3 per cent.	1 litre at 15° C. contains grams NH_3.
0·882	34·95	308·3	0·910	24·99	227·4
·884	34·10	301 4	·912	24·33	221·9
·886	33·25	294·6	·914	23·68	216·3
·888	32·50	288·6	·916	23·03	210·9
·890	31·75	282·6	·918	22·39	205·6
·892	31·05	277·0	·920	21·75	200·1
·894	30·37	271·5	·922	21·12	194·7
·896	29·69	266·0	·924	20·49	189·3
·898	29·01	260·5	·926	19·87	184·2
·900	28·33	255·0	·928	19·25	178·6
·902	27·65	249·4	·930	18·64	173·4
·904	26·98	243·9	·932	18·03	168·1
·906	26·31	238·3	·934	17·42	162·7
·908	25·65	232·9	·936	16·82	157·4

SPECIFIC GRAVITIES OF AQUEOUS AMMONIA—*continued.*

Specific gravity at 15° C.	NH_3 per cent.	1 litre at 15° C. contains — grams NH_3.	Specific gravity at 15° C.	NH_3 per cent.	1 litre at 15° C. contains grams NH_3.
0·938	16·22	152·1	0·970	7·31	70·9
·940	15·63	146·9	·972	6·80	66·1
·942	15·04	141·7	·974	6·30	61·4
·944	14·46	136·5	·976	5·80	56·6
·946	13·88	131·3	·978	5·30	51·8
·948	13·31	126·2	·980	4·80	47·0
·950	12·74	121·0	·982	4·30	42·2
·952	12·17	115·9	·984	3·80	37·4
·954	11·60	110·7	·986	3·30	32·5
·956	11·03	105·4	·988	2·80	27·7
·958	10·47	100·3	·990	2·31	22·9
·960	9·91	95·1	·992	1·84	18·2
·962	9·35	89·9	·994	1·37	13·6
·964	8·84	85·2	·996	0·91	9·1
·966	8·33	80·5	·998	0·45	4·5
·968	7·82	75·7	1·000	0·00	0·0

SPECIFIC GRAVITIES OF SOLUTIONS OF SODIUM AND POTASSIUM HYDROXIDES AT 15°/4° C.

Sp. gr.	% NaOH.	% KOH.	Sp. gr.	% NaOH.	% KOH.
1·010	0·86	1·18	1·280	25·04	29·00
1·020	1·69	2·28	1·290	25·96	29·96
1·030	2·60	3·36	1·300	26·85	30·91
1·040	3·50	4·44	1·310	27·85	31·84
1·050	4·34	5·53	1·320	28·83	32·78
1·060	5·20	6·60	1·330	29·80	33·70
1·070	6·13	7·68	1·340	30·74	34·63
1·080	7·05	8·76	1·350	31·75	35·55
1·090	7·95	9·82	1·360	32·79	36·46
1·100	8·78	10·87	1·370	33·73	37·37
1·110	9·67	11·92	1·380	34·71	38·28
1·120	10·56	12·96	1·390	35·68	39·18
1·130	11·55	14·01	1·400	36·67	40·09
1·140	12·49	15·04	1·410	37·65	40·98
1·150	13·34	16·08	1·420	38·67	41·87
1·160	14·19	17·10	1·430	39·67	42·76
1·170	15·06	18·13	1·440	40·68	43·63
1·180	16·00	19·15	1·450	41·70	44·50
1·190	16·91	20·17	1·460	42·75	45·37
1·200	17·81	21·17	1·470	43·80	46·23
1·210	18·71	22·16	1·480	44·85	47·09
1·220	19·65	23·17	1·490	45·89	47·93
1·230	20·60	24·14	1·500	46·94	48·78
1·240	21·47	25·13	1·510	48·00	49·64
1·250	22·38	26·10	1·520	49·05	50·48
1·260	23·23	27·07	1·530	50·10	51·32
1·270	24·18	28·04			

The above table is abbreviated from the very full tables given in Lunge's *Technical Chemists' Handbook* (1908).

STRENGTH OF SATURATED SOLUTIONS OF A FEW COMMON SALTS.*

	At 60° F.		
	Sp. gr. of saturated solution.	C.c. of water dissolve 1 gram.	Grams in 1 litre of saturated solution.
Acid, chromic	1·710	0·59	1075·5
,, citric	1·3026	0·51	861·7
,, tartaric	1·31	0·71	766·1
Alum, ammonia	1·0459	9·95	95·5
,, potash	1·046	9·70	97·7
Ammonium carbonate	1·094	3·94	221·5
,, chloride	1·077	2·8	472·4
Borax	1·0205	23·7	41·3
Calcium chloride (anhyd.)	1·4096	1·41	584·6
,, ,, ($CaCl_2, 2H_2O$)	1·4096	0·82	774·2
Copper sulphate	1·193	2·79	314·8
Lead acetate	1·2554	2·37	372·5
Magnesium sulphate	1·2755	0·98	643·9
Mercuric chloride	1·0472	17·9	55·4
Potassium acetate	1·406	0·28	1099·2
,, bicarbonate	1·1688	3·21	277·7
,, dichromate	1·066	9·93	97·5
,, bromide	1·3615	1·59	525·7
,, chlorate	1·038	16·53	59·2
,, hydrate	1·553	0·647	942·9
,, iodide	1·7039	0·701	996·4
,, nitrate	1·1452	3·77	240·1
,, permanganate	1·0368	18·7	52·7
,, sulphate	1·0784	9·65	101·3
Sodium bicarbonate	1·0608	11·08	87·8
,, carbonate	1·1608	1·66	436·4
,, chloride	1·204	2·8	316·8
,, phosphate	1·0489	6·91	132·6
,, sulphate	1·1114	2·68	302·7
Zinc sulphate	1·452	0·65	880·0

Note.—In all the above determinations the substances are calculated as of official (*i.e.*, B.P.), not absolute, purity.

* H. G. Greenish in the *Pharm. Journal*, Dec. 26, 1903.

GLYCERINE TABLE.

Per cent. Glycerine.	Sp. gr. $\frac{15^{\circ}\text{ C.}}{15^{\circ}} = \frac{59^{\circ}\text{ F.}}{59^{\circ}}$	Sp. gr. $\frac{20^{\circ}\text{ C.}}{20^{\circ}} = \frac{68^{\circ}\text{ F.}}{68^{\circ}}$	Per cent. Glycerine.	Sp. gr. $\frac{15^{\circ}\text{ C.}}{15^{\circ}}$	Per cent. Glycerine.	Sp. gr. $\frac{15^{\circ}\text{ C.}}{15^{\circ}}$
100	1·26596	1·26348	74	1·19583	40	1·10258
99	1·26335	1·26085	73	1·19309	35	1·08908
98	1·26072	1·25822	72	1·19035	30	1·07564
97	1·25809	1·25560	71	1·18761	25	1·06236
96	1·25547	1·25297	70	1·18487	20	1·04930
95	1·25285	1·25034	69	1·18212	15	1·03652
94	1·25021	1·24771	68	1·17937	10	1·02409
93	1·24756	1·24508	67	1·17662	5	1·01189
92	1·24487	1·24246	66	1·17387		
91	1·24217	1·23983	65	1·17113		
90	1·23945	1·23720	64	1·16837		
89	1·23678	1·23449	63	1·16561		
88	1·23400	1·23178	62	1·16286		Sp. gr. $\frac{20^{\circ}\text{ C.}}{20^{\circ}}$
87	1·23128	1·22907	61	1·16011		
86	1·22855	1·22636	60	1·15737		
85	1·22583	1·22365	59	1·15462		
84	1·22310	1·22094	58	1·15187		
83	1·22038	1·21823	57	1·14912	70	1·18293
82	1·21766	1·21552	56	1·14637	60	1·15561
81	1·21493	1·21281	55	1·14362	50	1·12831
80	1·21221	1·21010	54	1·14088	40	1·10118
79	1·20949	1·20737	53	1·13814	30	1·07469
78	1·20677	1·20464	52	1·13539	20	1·04884
77	1·20404	1·20190	51	1·13265	10	1·02391
76	1·20131	1·19917	50	1·12990		
75	1·19857	1·19644	45	1·11618		

The above table is a combination of W. W. J. Nicol's excellent tables for the two temperatures above specified, as given in the *United States Dispensatory*, p. 653, and in Watts's *Dictionary of Chemistry* (most recent edition in each case). In the former work a complete table from 1–100°/o glycerine, at 15° C. is given.

The following formula is useful :—

$$\frac{\text{sp. gr. of dilute glycerine}-1{\cdot}000}{{\cdot}002665} = {}^{\circ}/_{\circ}\text{ by weight of glycerine.}$$

The divisor ·00261 is more accurate, however, for mixtures containing between 30 and 60°/o glycerine, and ·0025 for those below 30°/o.

The Preparation of Reagents for Water Analysis.

Nessler's Solution.—First, dissolve 150 grams of stick potash in 150 c.c. of water, and set aside to cool. Next, dissolve 62·5 grams of potassium iodide in about 250 c.c. of water in a 1200 c.c. beaker, transfer about 10 c.c. to a small beaker, and add gradually to the main bulk, with constant stirring, a cold saturated solution of mercuric chloride (of which about 500 c.c. will be required) until a permanent precipitate is obtained. Now add the potassium iodide solution in the small beaker, which should redissolve the precipitate, and continue adding cautiously mercuric chloride until a slight precipitate remains undissolved on stirring. Add the cold potash solution, transfer the whole to a litre flask, make up to the mark with water, and pour into a stoppered bottle. After standing about 12 hours the solution will have become clear, and should then be tested as follows: To 50 c.c. of ammonia-free water add 0·2 c.c. of standard ammonium chloride solution (=0·00001 gram NH_3), mix, and then add 2 c.c. of Nessler's solution, when a yellow tinge should appear *at once* if the latter solution be properly made. If the Nessler's solution is not sensitive—which will be the case if it is perfectly colourless, instead of the proper greenish-yellow tint—a little more mercuric chloride solution should be added, the whole well mixed, allowed to settle, and tested again.

Some Nessler's solutions give a red precipitate when added to water. The art of making a thoroughly satisfactory Nessler's solution can only be acquired by practice.

Alkaline permanganate solution.—Dissolve 200 grams of stick potash in water in a large porcelain dish and add a solution of 8 grams of potassium permanganate in water, using 1100 c.c. altogether. Boil rapidly until concentrated to about 900 c.c., add about 200 c.c. of hot distilled water, and continue boiling till the volume is reduced to a litre. When cool, pour at once into a bottle. Every fresh lot of solution made should be carefully tested before being used.

Standard solution of ammonium chloride.—Dissolve 1·5704 grams of pure dry ammonium chloride in a litre of ammonia-free water; of this take 100 c.c. and make up to a litre with water. Of this latter solution

1 c.c. = 0·00005 gram ammonia.
1·21 c.c. = 0·00005 gram nitrogen.

When 500 c.c. of water are distilled,

1 c.c. = 0·01 part NH_3 per 100,000.
1·21 c.c. = 0·01 part N ,,

The solution should be measured in a standard 1 c.c. pipette divided into hundredths.

Or, by dissolving 1·9094 gm. NH_4Cl in a litre of water, and diluting 100 c.c. of the solution to 1000 c.c., then of this latter solution

1 c.c. = 0·00005 gram ammoniacal nitrogen.

Standard silver nitrate solution.—Dissolve 2·4 grams of recryst. silver nitrate in a litre of water and standardize against a solution of pure sodium chloride containing 0·8243 gram per litre (1 c.c. = 0·0005 gram chlorine).

1 c.c. silver nitrate solution = 0·0005 gram Cl,

or when 50 c.c. of water are titrated,

1 c.c. = 1 part combined chlorine per 100,000.

Reagents for Determination of Oxygen Absorbed.

(i) *Dilute sulphuric acid.*—Add 1 vol. of pure sulphuric acid to 3 vols. of water, and drop in potassium permanganate solution (ii) until the liquid retains a *very faint* pink tint after being kept at 80° F. for four hours.

(ii) *Standard solution of potassium permanganate.*—Dissolve 0·395 gram of recryst. potassium permanganate in 1 litre of water.

1 c.c. = 0·0001 gram available oxygen.

(iii) *Potassium iodide solution.*—Dissolve 1 part of the pure salt in 10 parts of water.

(iv) *Sodium thiosulphate solution.*—Dissolve 1 gram of the crystals in 1 litre of water.

(v) *Starch indicator.*—One part of clean potato starch, or arrowroot, is mixed smoothly into an emulsion with cold water, then poured gradually into about 150 or 200 times its weight of boiling water, the boiling continued for a few minutes, then allowed to stand and settle thoroughly. The clear solution only is to be used as the indicator, of which only a few drops are necessary.

Lintner's soluble starch acts well as an indicator, as it gives at once a clear solution in boiling water.

Thresh's starch solution (see p. 94) is also useful as an indicator.

Reagents Required for Determination of Hardness.

Preparation of soap solution for Clark's test.—Weigh out 50 grams of commercial oleic acid in a beaker and add 100 c.c. of an alcoholic potash solution made by dissolving 20 grams of stick potash in 180 c.c. of *industrial* methylated spirit, and continue adding the same solution from a burette till a drop of the oleate just gives a red colour with phenol-phthalein spotted on a white tile—about 10 c.c. more being required. Measure the solution and make the volume to 400 c.c. by the addition of methylated spirit. 45 c.c. of the strong soap solution thus obtained are diluted with methylated spirit (2 vols.) and water (1 vol.) to a litre, allowed to stand for about 24 hours, filtered through a double Swedish filter, and standardized against standard calcium chloride

solution. The solution will be found to be a little too strong, and is diluted to exact strength, which is attained when 14·25 c.c. are required to form a permanent lather with 50 c.c. of the standard calcium chloride solution.

Standard calcium chloride solution.—Dissolve 0·2 gram of Iceland spar in dilute hydrochloric acid in a platinum dish, adding the acid gradually and having the dish covered with a large watch glass to prevent loss by spirting. When solution has taken place, rinse the glass into the dish, and evaporate to dryness on a water-bath: add water and again evaporate to dryness, and repeat this addition of water and evaporation two or three times in order to ensure complete expulsion of hydrochloric acid. Finally, take up the residue with distilled water, and make up the solution to 1 litre.

50 c.c. correspond to 0·01 gram $CaCO_3$.

Tables required in Water Analysis.

I. *Tension of Aqueous Vapour in Millimetres of Mercury from 0° to 35° C.*

°C.	mm.	°C.	mm.	°C.	mm.	°C.	mm.	°C.	mm.
0·0	4·600	2·5	5·491	5·0	6·534	7·5	7·751	10·0	9·165
·1	·633	·6	·530	·1	·580	·6	·804	·1	·227
·2	·667	·7	·569	·2	·625	·7	·857	·2	·288
·3	·700	·8	·608	·3	·671	·8	·910	·3	·350
·4	·733	·9	·647	·4	·717	·9	·964	·4	·412
0·5	·767	3·0	5·687	5·5	·763	8·0	8·017	10·5	·474
·6	·801	·1	·727	·6	·810	·1	·072	·6	·537
·7	·836	·2	·767	·7	·857	·2	·126	·7	·601
·8	·871	·3	·807	·8	·904	·3	·181	·8	·665
·9	·905	·4	·848	·9	·951	·4	·236	·9	·728
1·0	4·940	3·5	·890	6·0	6·998	8·5	·291	11·0	9·792
·1	·975	·6	·930	·1	7·047	·6	·347	·1	·857
·2	5·011	·7	·972	·2	·095	·7	·404	·2	·923
·3	·047	·8	6·014	·3	·144	·8	·461	·3	·989
·4	·082	·9	·056	·4	·193	·9	·517	·4	10·054
1·5	·118	4·0	6·097	6·5	·242	9·0	8·574	11·5	·120
·6	·155	·1	·140	·6	·292	·1	·632	·6	·187
·7	·191	·2	·183	·7	·342	·2	·690	·7	·255
·8	·228	·3	·226	·8	·392	·3	·748	·8	·322
·9	265	·4	·270	·9	·442	·4	·807	·9	·389
2·0	5·302	4·5	·313	7·0	7·492	9·5	·865	12·0	10·457
·1	·340	·6	·357	·1	·544	·6	·925	·1	·526
·2	·378	·7	·401	·2	·595	·7	·985	·2	·596
·3	·416	·8	·445	·3	·647	·8	9·045	·3	·665
·4	·454	·9	·490	·4	·699	·9	·105	·4	·734

TABLES REQUIRED IN WATER ANALYSIS. TABLE I.—*continued.*

°C.	mm.	°C.	mm.	°C.	mm.	°C.	mm.	°C.	mm.
12·5	10·804	17·1	14·513	21·7	19·305	26·3	25·438	30·9	33·215
·6	·875	·2	·605	·8	·423	·4	·588	31·0	33·405
·7	·947	·3	·697	·9	·541	26·5	·738	·1	·596
·8	11·019	·4	·790	22·0	19·659	·6	·891	·2	·787
·9	·090	17·5	·882	·1	·780	·7	26·045	·3	·980
13·0	11·162	·6	·977	·2	·901	·8	·198	·4	34·174
·1	·235	·7	15·072	·3	20·022	·9	·351	31·5	·368
·2	·309	·8	·167	·4	·143	27·0	26·505	·6	·564
·3	·383	·9	·262	22·5	·265	·1	·663	·7	·761
·4	·456	18·0	15·357	·6	·389	·2	·820	·8	·959
13·5	·530	·1	·454	·7	·514	·3	·978	·9	35·159
·6	·605	·2	·552	·8	·639	·4	27·136	32·0	35·359
·7	·681	·3	·650	·9	·763	27·5	·294	·1	·559
·8	·757	·4	·747	23·0	20·888	·6	·455	·2	·760
·9	·832	18·5	·845	·1	21·016	·7	·617	·3	·962
14·0	11·908	·6	·945	·2	·144	·8	·778	·4	36·165
·1	·986	·7	16·045	·3	·272	·9	·939	32·5	·370
·2	12·064	·8	·145	·4	·400	28·0	28·101	·6	·576
·3	·142	·9	·246	23·5	·528	·1	·267	·7	·783
·4	·220	19·0	16·346	·6	21·659	·2	·433	·8	·991
14·5	·298	·1	·449	·7	·790	·3	·599	·9	37·200
·6	·378	·2	·552	·8	·921	·4	·765	33·0	37·410
·7	·458	·3	·655	·9	22·053	28·5	·931	·1	·621
·8	·538	·4	·758	24·0	22·184	·6	29·101	·2	·832
·9	·619	19·5	·861	·1	·319	·7	·271	·3	38·045
15·0	12·699	·6	·967	·2	·453	·8	·441	·4	·258
·1	·781	·7	17·073	·3	·588	·9	·612	33·5	·473
·2	·864	·8	·179	·4	·723	29·0	29·782	·6	·689
·3	·947	·9	·285	24·5	·858	·1	·956	·7	·906
·4	13·029	20·0	17·391	·6	·996	·2	30·131	·8	39·124
15·5	·112	·1	·500	·7	23·135	·3	·305	·9	·344
·6	·197	·2	·608	·8	·273	·4	·479	34·0	39·565
·7	·281	·3	·717	·9	·411	29·5	·654	·1	·786
·8	·366	·4	·826	25·0	23·550	·6	·833	·2	40·007
·9	·451	20·5	·935	·1	·692	·7	31·011	·3	·230
16·0	13·536	·6	18·047	·2	·834	·8	·190	·4	·455
·1	·623	·7	·159	·3	·976	·9	·369	34·5	·680
·2	·710	·8	·271	·4	24·119	30·0	31·548	·6	·907
·3	·797	·9	·383	25·5	·261	·1	·729	·7	41·135
·4	·885	21·0	18·495	·6	·406	·2	·911	·8	·364
16·5	·972	·1	·610	·7	·552	·3	32·094	·9	·595
·6	14·062	·2	·724	·8	·697	·4	·278	35·0	·827
·7	·151	·3	·839	·9	·842	30·5	·463		
·8	·241	·4	·954	26·0	24·988	·6	·650		
·9	·331	21·5	19·069	·1	25·138	·7	·837		
17·0	14·421	·6	·187	·2	·288	·8	33·026		

TABLES REQUIRED IN WATER ANALYSIS—*continued.*

II. *Reduction of Cubic Centimetres of Nitrogen to Grams.*

Log. $\frac{0{\cdot}0012507}{(1 + {\cdot}003665\ t)\ 760}$ for each tenth of a degree from 0° to 30° C.

t.	0·0	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9
° C.										
0	$\bar{6}$·21634	618	602	586	570	554	539	523	507	491
1	475	459	443	427	411	395	379	363	347	332
2	317	301	285	269	253	237	221	205	189	174
3	159	143	127	112	096	080	065	049	033	018
4	002	$\overline{986}$	$\overline{970}$	$\overline{955}$	$\overline{939}$	$\overline{923}$	$\overline{908}$	$\overline{892}$	$\overline{876}$	$\overline{861}$
5	$\bar{6}$·20845	829	813	798	782	766	751	735	719	704
6	$\bar{6}$·20689	673	658	642	627	611	596	580	565	549
7	534	518	503	487	472	456	441	425	410	394
8	379	364	348	333	317	302	286	271	255	240
9	225	210	194	179	163	148	132	117	101	086
10	071	056	040	025	009	$\overline{994}$	$\overline{979}$	$\overline{963}$	$\overline{948}$	$\overline{932}$
11	$\bar{6}$·19917	902	887	872	856	841	826	811	796	780
12	$\bar{6}$·19765	750	735	720	704	689	674	659	644	628
13	613	598	583	568	552	537	522	507	492	476
14	461	446	431	416	401	386	371	356	341	325
15	310	295	280	265	250	235	220	205	190	174
16	159	144	129	114	099	084	069	054	039	024
17	009	$\overline{994}$	$\overline{979}$	$\overline{964}$	$\overline{949}$	$\overline{934}$	$\overline{919}$	$\overline{904}$	$\overline{889}$	$\overline{874}$
18	$\bar{6}$·18859	844	829	814	799	784	769	754	739	724
19	710	695	680	665	650	635	620	606	591	576
20	562	547	532	517	502	487	472	458	443	428
21	414	399	384	369	354	339	324	310	295	280
22	266	251	236	221	206	191	176	162	147	132
23	119	104	089	075	060	045	031	016	002	$\overline{987}$
24	$\bar{6}$·17973	958	943	929	914	899	885	870	856	841
25	827	812	797	783	768	753	739	724	710	695
26	681	666	651	637	622	607	593	578	564	549
27	536	521	507	492	478	463	449	434	420	405
28	391	376	362	347	333	318	304	289	275	260
29	247	232	218	203	189	175	160	146	131	117

TABLES REQUIRED IN WATER ANALYSIS—*continued.*

III. *Loss of Nitrogen by Evaporation of NH_3 with Sulphurous Acid.*

Parts per 100,000.

NH_3	Loss of N	NH_3	Loss of N	NH_3	Loss of N	NH_3	Loss of N	NH_3	Loss of N	NH_3	Loss of N
6·0	1·727	4·8	1·451	3·6	·977	2·4	·508	1·2	·250	·09	·014
5·9	1·707	4·7	1·411	3·5	·937	2·3	·463	1·1	·238	·08	·013
5·8	1·688	4·6	1·372	3·4	·898	2·2	·424	1·0	·226	·07	·012
5·7	1·668	4·5	1·332	3·3	·858	2·1	·384	0·9	·196	·06	·010
5·6	1·648	4·4	1·293	3·2	·819	2·0	·345	·8	·166	·05	·009
5·5	1·628	4·3	1·253	3·1	·779	1·9	·333	·7	·136	·04	·007
5·4	1·609	4·2	1·214	3·0	·740	1·8	·321	·6	·106	·03	·006
5·3	1·589	4·1	1·174	2·9	·700	1·7	·309	·5	·077	·02	·004
5·2	1·569	4·0	1·135	2·8	·661	1·6	·297	·4	·062	·01	·003
5·1	1·549	3·9	1·095	2·7	·621	1·5	·285	·3	·047	·009	·001
5·0	1·530	3·8	1·056	2·6	·582	1·4	·274	·2	·032		
4·9	1·490	3·7	1·016	2·5	·542	1·3	·262	·1	0·17		

IV. *Loss of Nitrogen by Evaporation of NH_3 with Hydric Metaphosphate.*

Parts per 100,000.

Volume evaporated.	NH_3	Loss of N	Volume evaporated.	NH_3	Loss of N	Volume evaporated.	NH_3	Loss of N
100 c.c.	10·0	·483	100 c.c.	8·3	·424	100 c.c.	6·6	·365
,,	9·9	·480	,,	8·2	·421	,,	6·5	·361
,,	9·8	·476	,,	8·1	·417	,,	6·4	·358
,,	9·7	·473	,,	8·0	·414	,,	6·3	·354
,,	9·6	·469	,,	7·9	·410	,,	6·2	·351
,,	9·5	·466	,,	7·8	·407	,,	6·1	·348
,,	9·4	·462	,,	7·7	·403	,,	6·0	·345
,,	9·3	·459	,,	7·6	·400	,,	5·9	·341
,,	9·2	·455	,,	7·5	·396	,,	5·8	·337
,,	9·1	·452	,,	7·4	·393	,,	5·7	·333
,,	9·0	·448	,,	7·3	·389	,,	5·6	·330
,,	8·9	·445	,,	7·2	·386	,,	5·5	·326
,,	8·8	·441	,,	7·1	·382	,,	5·4	·322
,,	8·7	·438	,,	7·0	·379	,,	5·3	·318
,,	8·6	·434	,,	6·9	·375	,,	5·2	·314
,,	8·5	·431	,,	6·8	·372	,,	5·1	·310
,,	8·4	·428	,,	6·7	·368	,,	5·0	·306

TABLES REQUIRED IN WATER ANALYSIS. TABLE IV.—*continued.*

Volume evaporated.	NH_3	Loss of N	Volume evaporated.	NH_3	Loss of N	Volume evaporated.	NH_3	Loss of N
100 c.c.	4·9	·302	100 c.c.	2·9	·211	250 c.c.	·9	·096
,,	4·8	·298	,,	2·8	·205	,,	·8	·080
,,	4·7	·294	,,	2·7	·200	,,	·7	·070
,,	4·6	·291	,,	2·6	·195	,,	·6	·060
,,	4·5	·287	,,	2·5	·190	500 c.c.	·5	·050
,,	4·4	·283	,,	2·4	·184	,,	·4	·040
,,	4·3	·279	,,	2·3	·179	,,	·3	·030
,,	4·2	·275	,,	2·2	·174	1000 c.c.	·2	·020
,,	4·1	·271	,,	2·1	·169	,,	·1	·010
,,	4·0	·267	,,	2·0	·164	,,	·09	·009
,,	3·9	·262	,,	1·9	·158	,,	·08	·008
,,	3·8	·257	,,	1·8	·153	,,	·07	·007
,,	3·7	·252	,,	1·7	·148	,,	·06	·006
,,	3·6	·247	,,	1·6	·143	,,	·05	·005
,,	3·5	·242	,,	1·5	·137	,,	·04	·004
,,	3·4	·236	,,	1·4	·132	,,	·03	·003
,,	3·3	·231	,,	1·3	·127	,,	·02	·002
,,	3·2	·226	,,	1·2	·122	,,	·01	·001
,,	3·1	·221	,,	1·1	·117			
,,	3·0	·216	,,	1·0	·112			

V. *Loss of Nitrogen by Evaporation of NH_3 with Sulphurous Acid.*

Parts per 100,000.

N as NH_3	Loss of N	N as NH_3	Loss of N	N as NH_3	Loss of N	N as NH_3	Loss of N	N as NH_3	Loss of N	N as NH_3	Loss of N
5·0	1·741	3·9	1·425	2·9	·946	1·9	·466	·9	·237	·08	·017
4·9	1·717	3·8	1·378	2·8	·898	1·8	·418	·8	·217	·07	·015
4·8	1·693	3·7	1·330	2·7	·850	1·7	·370	·7	·181	·06	·013
4·7	1·669	3·6	1·282	2·6	·802	1·6	·338	·6	·145	·05	·011
4·6	1·645	3·5	1·234	2·5	·754	1·5	·324	·5	·109	·04	·009
4·5	1·621	3·4	1·186	2·4	·706	1·4	·309	·4	·075	·03	·007
4·4	1·598	3·3	1·138	2·3	·658	1·3	·295	·3	·057	·02	·005
4·3	1·574	3·2	1·090	2·2	·610	1·2	·280	·2	·038	·01	·003
4·2	1·550	3·1	1·042	2·1	·562	1·1	·266	·1	·020	·008	·002
4·1	1·521	3·0	·994	2·0	·514	1·0	·252	·09	·018	·007	·001
4·0	1·478										

TABLES REQUIRED IN WATER ANALYSIS—*continued.*

VI. *Loss of Nitrogen by Evaporation of NH_3 with Hydric Metaphosphate.*

Parts per 100,000.

Volume evaporated.	N as NH_3	Loss of N	Volume evaporated.	N as NH_3	Loss of N	Volume evaporated.	N as NH_3	Loss of N
100 c.c.	8·2	·482	100 c.c.	5·1	·352	100 c.c.	2·1	·192
,,	8·1	·477	,,	5·0	·347	,,	2·0	·186
,,	8·0	·473	,,	4·9	·343	,,	1·9	·180
,,	7·9	·469	,,	4·8	·338	,,	1·8	·173
,,	7·8	·465	,,	4·7	·334	,,	1·7	·167
,,	7·7	·461	,,	4·6	·329	,,	1·6	·161
,,	7·6	·456	,,	4·5	·324	,,	1·5	·154
,,	7·5	·452	,,	4·4	·319	,,	1·4	·148
,,	7·4	·448	,,	4·3	·315	,,	1·3	·142
,,	7·3	·444	,,	4·2	·310	,,	1·2	·136
,,	7·2	·440	,,	4·1	·305	,,	1·1	·129
,,	7·1	·435	,,	4·0	·301	,,	1·0	·123
,,	7·0	·431	,,	3·9	·296	,,	·9	·117
,,	6·9	·427	,,	3·8	·291	,,	·8	·111
,,	6·8	·423	,,	3·7	·286	250 c.c.	·7	·088
,,	6·7	·419	,,	3·6	·281	,,	·6	·073
,,	6·6	·414	,,	3·5	·277	,,	·5	·061
,,	6·5	·410	,,	3·4	·272	500 c.c.	·4	·049
,,	6·4	·406	,,	3·3	·267	,,	·3	·036
,,	6·3	·402	,,	3·2	·261	1000 c.c.	·2	·024
,,	6·2	·398	,,	3·1	·255	,,	·1	·012
,,	6·1	·394	,,	3·0	·249	,,	·09	·011
,,	6·0	·389	,,	2·9	·242	,,	·08	·010
,,	5·9	·385	,,	2·8	·236	,,	·07	·008
,,	5·8	·381	,,	2·7	·230	,,	·06	·007
,,	5·7	·377	,,	2·6	·223	,,	·05	·006
,,	5·6	·373	,,	2·5	·217	,,	·04	·005
,,	5·5	·368	,,	2·4	·211	,,	·03	·004
,,	5·4	·364	,,	2·3	·205	,,	·02	·002
,,	5·3	·360	,,	2·2	·198	,,	·01	·001
,,	5·2	·356						

VII. *Table of Hardness.*

(50 c.c. of water used.)

Volume of Soap solution.	$CaCO_3$ per 100,000	Degrees of Hardness.*	Volume of Soap solution.	$CaCO_3$ per 100,000	Degrees of Hardness.	Volume of Soap solution.	$CaCO_3$ per 100,000	Degrees of Hardness.
c.c.			c.c.			c.c.		
0·7	0·00	0·00	1·3	0·95	0·67	1·9	1·82	1·27
0·8	0·16	0·11	·4	1·11	0·78	2·0	1·95	1·37
0·9	0·32	0·22	·5	1·27	0·89	·1	2·08	1·46
1·0	0·48	0·34	·6	1·43	1·00	·2	2·21	1·55
·1	0·63	0·44	·7	1·56	1·09	·3	2·34	1·64
·2	0·79	0·55	·8	1·69	1·18	·4	2·47	1·73

* Each degree of hardness indicates one grain of $CaCO_3$ per gallon.

TABLES REQUIRED IN WATER ANALYSIS. TABLE VII.—*continued.*

Volume of Soap solution.	$CaCO_3$ per 100,000	Degrees of Hardness.*	Volume of Soap solution.	$CaCO_3$ per 100,000	Degrees of Hardness.	Volume of Soap solution.	$CaCO_3$ per 100,000	Degrees of Hardness.
c.c.			c.c.			c.c.		
2·5	2·60	1·82	7·1	9·00	6·30	11·7	15·95	11·17
·6	2·73	1·91	·2	9·14	6·40	·8	16·11	11·28
·7	2·86	2·00	·3	9·29	6·50	·9	16·27	11·39
·8	2·99	2·09	·4	9·43	6·60	12·0	16·43	11·50
·9	3·12	2·18	·5	9·57	6·70	·1	16·59	11·61
3·0	3·25	2·28	·6	9·71	6·80	·2	16·75	11·73
·1	3·38	2·37	·7	9·86	6·90	·3	16·90	11·83
·2	3·51	2·46	·8	10·00	7·00	·4	17·06	11·94
·3	3·64	2·55	·9	10·15	7·11	·5	17·22	12·05
·4	3·77	2·64	8·0	10·30	7·21	·6	17·38	12·17
·5	3·90	2·73	·1	10·45	7·32	·7	17·54	12·28
·6	4·03	2·82	·2	10·60	7·42	·8	17·70	12·39
·7	4·16	2·91	·3	10·75	7·53	·9	17·86	12·50
·8	4·29	3·00	·4	10·90	7·63	13·0	18·02	12·61
·9	4·43	3·10	·5	11·05	7·74	·1	18·17	12·72
4·0	4·57	3·20	·6	11·20	7·84	·2	18·33	12·83
·1	4·71	3·30	·7	11·35	7·95	·3	18·49	12·94
·2	4·86	3·40	·8	11·50	8·05	·4	18·65	13·06
·3	5·00	3·50	·9	11·65	8·16	·5	18·81	13·17
·4	5·14	3·60	9·0	11·80	8·26	·6	18·97	13·28
·5	5·29	3·70	·1	11·95	8·37	·7	19·13	13·39
·6	5·43	3·80	·2	12·11	8·48	·8	19·29	13·50
·7	5·57	3·90	·3	12·26	8·58	·9	19·44	13·61
·8	5·71	4·00	·4	12·41	8·69	14·0	19·60	13·72
·9	5·86	4·10	·5	12·56	8·79	·1	19·76	13·83
5·0	6·00	4·20	·6	12·71	8·90	·2	19·92	13·94
·1	6·14	4·30	·7	12·86	9·00	·3	20·08	14·06
·2	6·29	4·40	·8	13·01	9·11	·4	20·24	14·17
·3	6·43	4·50	·9	13·16	9·21	·5	20·40	14·28
·4	6·57	4·60	10·0	13·31	9·32	·6	20·56	14·39
·5	6·71	4·70	·1	13·46	9·42	·7	20·71	14·50
·6	6·86	4·80	·2	13·61	9·53	·8	20·87	14·61
·7	7·00	4·90	·3	13·76	9·63	·9	21·03	14·72
·8	7·14	5·00	·4	13·91	9·74	15·0	21·19	14·83
·9	7·29	5·10	·5	14·06	9·84	·1	21·35	14·95
6·0	7·43	5·20	·6	14·21	9·95	·2	21·51	15·06
·1	7·57	5·30	·7	14·37	10·06	·3	21·68	15·18
·2	7·71	5·40	·8	14·52	10·16	·4	21·85	15·30
·3	7·86	5·50	·9	14·68	10·28	·5	22·02	15·41
·4	8·00	5·60	11·0	14·84	10·39	·6	22·18	15·53
·5	8·14	5·70	·1	15·00	10·50	·7	22·35	15·65
·6	8·29	5·80	·2	15·16	10·61	·8	22·52	15·76
·7	8·43	5·90	·3	15·32	10·72	·9	22·69	15·88
·8	8·57	6·00	·4	15·48	10·84	16·0	22·86	16·00
·9	8·71	6·10	·5	15·63	10·94			
7·0	8·86	6·20	·6	15·79	11·05			

* Each degree of hardness indicates one grain of $CaCO_3$ per gallon.

TABLES REQUIRED IN WATER ANALYSIS—*continued.*

VIII. *Clark's Table of Hardness of Water.*

Degrees of Hardness.	Measures of Soap solution.	Differences for the next 1° of Hardness.	Degrees of Hardness.	Measures of Soap solution.	Differences for the next 1° of Hardness.
0 (distilled water)	1·4	1·8	8	17·5	1·9
1	3·2	2·2	9	19·4	1·9
2	5·4	2·2	10	21·3	1·8
3	7·6	2·0	11	23·1	1·8
4	9·6	2·0	12	24·9	1·8
5	11·6	2·0	13	26·7	1·8
6	13·6	2·0	14	28·5	1·8
7	15·6	1·9	15	30·3	1·7
			16	32·0	...

Each measure equals 10 grains, the quantity of water operated upon equals 1000 grains, and each "degree of hardness" indicates 1 grain of calcic carbonate per gallon.

THE DETERMINATION OF NITRATES IN WATER BY PHENOL-DISULPHONIC ACID.

(Sprengel's method modified.)

Solutions required.

(1) *Phenol-disulphonic Acid.*—Mix together 2 parts by measure of phenol,* liquefied by heat, and 5 parts of pure concentrated sulphuric acid, and heat in a porcelain basin on the water-bath for about 8 hours, with occasional stirring. When cool, add 1½ volumes of water and ½ volume strong hydrochloric acid to each volume of the phenol-disulphonic acid.

Convenient quantities are 80 c.c. phenol, 200 c.c. H_2SO_4; 420 c.c. water and 140 c.c. HCl, producing 840 c.c. of a light brown solution, which is ready for immediate use.

(2) *Standard Potassium Nitrate.*—0·0722 gram KNO_3 crystals are dissolved in a litre of water.†

10 c.c. = 0·0001 gram N, or 1 part of N in 100,000 of water when 10 c.c. are evaporated.

(3) 10% ammonia (1 vol. ·880 + 2 vols. water); or potash solution, made by dissolving 330 grams stick potash in one litre of water.

About 15 c.c. of either of the above to be used for each residue.

The determination is made as follows:—10 c.c. of the water under examination and 10 c.c. standard KNO_3 are pipetted into 15 c.c. beakers and evaporated nearly to dryness on a hot iron plate, the

* Calvert's No. 2 medical carbolic acid answers well.

† Or dissolve 0·7217 gram KNO_3 in a litre of distilled water. 1 c.c. of this may be used for a standard, but it is better to dilute 50 c.c. to 500 c.c. and measure out 10 c.c. of the latter for each set of determinations.

operation being completed on the top of the water-oven. To each residue 1 c.c. of the phenol-disulphonic acid solution is added, and the latter brought into contact with the whole of the residue in each beaker. This is done simply by rotating the beaker, held in an inclined position, until the entire residue has been moistened: no stirring rod is required. The beakers are then left on the top of the water-oven for 15 minutes and at the end of that time are at once filled up with cold water and removed to the working-bench, if a number of residues are being treated simultaneously. The standard solution is then rinsed into a 100 c.c. graduated cylinder, a slight excess (about 15 c.c.) of 10% ammonia or of caustic potash solution added, the 100 c.c. made up by the addition of water, and the yellow liquid transferred to a Nessler glass ($6 \times 1\frac{1}{2}$ ins.). Each of the other beakers is then successively treated in the same way and comparison made with the standard as in Nesslerizing. The colours are best compared when the Nessler glasses are held side by side at a short distance above a thick white filter paper.

The results obtained with the aid of Table IX. are only approximate when more than about 1·5 parts of nitric nitrogen per 100,000 of water are present. In all cases where the nitric nitrogen exceeds 1·5 parts per 100,000, it is necessary to make a second determination, using such a volume of water as to give a colour very nearly equal to that of the standard.* Thus, if a water showed 2 parts of nitric nitrogen per 100,000, 5 c.c. should be evaporated to dryness and treated as before; one giving 4 parts would really contain decidedly more, and 20 c.c. of the sample should be transferred to a 100 c.c. measuring flask, diluted to the mark with water, and 10 c.c. of the thoroughly mixed solution (= 2 c.c. original water) evaporated down for a fresh determination. In the case of very good waters, the solution and washings should be kept as small as possible, since a portion of the standard 100 c.c. will have to be poured into the cylinder in order to match the colours. Suppose that 0·25 part of nitric nitrogen is thus shown, then 40 c.c. of the water are measured into a larger beaker, evaporated to a small bulk, rinsed into a small beaker and evaporated to dryness, etc., as above; or 20 c.c. of the water may be taken and compared with a standard made by using only 5 c.c. of the KNO_3 solution. (This method is inapplicable in the presence of thiocyanates †).

Chamot, Pratt and Redfield ‡ have recently made a study of this method, and their results may briefly be summarized as follows:—

A modified phenol-sulphonic acid method.—Preparation of reagents required.

Phenol-disulphonic acid.—Dissolve 25 gm. of pure white phenol in 150 c.c. of pure concentrated sulphuric acid, add 75 c.c. of fuming sulphuric acid (13% SO_3), stir well, and heat for 2 hours at about 100° C.

* If the second experiment is to be made the same day, the same standard, if covered with a beaker, can be used again.

† See H. Silvester, *Journ. Soc. Chem. Ind.*, 1912, 31, 95.

‡ *The Chemical News*, 1911, 104, p. 146, *et seq.*

Standard silver sulphate.—4·3969 gm. of silver sulphate (free from nitrate) to the litre.

1 c.c. = 1 c.c. of standard $AgNO_3$ (1·6486 gm. per litre) equivalent to 0·001 gram chlorine.

Method of procedure.—First determine the alkalinity, the chlorine and nitrite content, and the colour of the sample. Should the colour be high, decolorize with "aluminium cream."

Measure out such a volume of the water (100 c.c. or less) as will contain about 1 part of nitric nitrogen per 100,000, fairly low colorimeter readings having been found most reliable. Add sufficient N/25 or N/50 sulphuric acid barely to neutralize the alkalinity, then enough standard silver sulphate solution to precipitate all but 0·5 mgm. of the chlorine. Heat to boiling, add a little aluminium cream, filter, and wash with small amounts of hot water. Evaporate the filtrates to dryness, add 2 c.c. of the disulphonic acid reagent, rubbing with a glass rod to ensure intimate contact. Should the residue be compact or vitreous in appearance from the presence of much magnesium or iron, place the evaporator on the water-bath for a few minutes. Dilute with water and add slowly KOH solution (10–12 normal) until the maximum colour is developed. Transfer to a colorimeter cylinder, filtering if necessary, and compare with a potassium nitrate or tripotassium nitrophenol disulphonate standard.

Should nitrites be present in excess of 0·1 part of nitrous nitrogen per 100,000, a slight error will be introduced. They should, therefore, be removed by heating the sample a few moments with a few drops of hydrogen peroxide (free from nitrates), repeatedly added, or dilute potassium permanganate may be added in the cold until a trace of pink appears and a correction applied to the final nitrate nitrogen reading due to the conversion of the nitrites to nitrates.

Directions for making permanent standards are given.

TABLES REQUIRED IN WATER ANALYSIS—*continued.*

IX. *Estimation of Nitrogen as Nitrates by Sprengel's Method (for waters containing more than one part of N in* 100,000).

No. of c.c. of yellow solution equal to the standard 100 c.c.	Nitrogen as Nitrates.		No. of c.c. of yellow solution equal to the standard 100 c.c.	Nitrogen as Nitrates.	
	Parts per 100,000.	Grains per gallon.		Parts per 100,000.	Grains per gallon.
100	1·00	0·70	50	2·00	1·40
95	1·05	0·74	48	2·08	1·46
90	1·11	0·78	46	2·17	1·52
85	1·18	0·83	45	2·22	1·55
80	1·25	0·88	44	2·27	1·59
78	1·28	0·90	42	2·38	1·67
76	1·32	0·92	40	2·50	1·75
75	1·33	0·93	38	2·63	1·84
74	1·35	0·95	36	2·78	1·95
72	1·39	0·97	35	2·86	2·00
70	1·43	1·00	34	2·94	2·06
68	1·47	1·03	32	3·13	2·19
66	1·51	1·06	30	3·33	2·33
65	1·54	1·08	28	3·57	2·50
64	1·55	1·09	26	3·85	2·70
62	1·61	1·13	25	4·00	2·80
60	1·67	1·17	24	4·17	2·92
58	1·72	1·20	22	4·55	3·19
56	1·78	1·25	20	5·00	3·50
55	1·82	1·27	18	5·55	3·89
54	1·85	1·30	16	6·25	4·38
52	1·92	1·34	15	6·67	4·67

X. *Table for the Conversion of Parts per* 100,000 *into Grains per Gallon.*

Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
1	0·7	9	6·3	17	11·9	25	17·5
2	1·4	10	7·0	18	12·6	26	18·2
3	2·1	11	7·7	19	13·3	27	18·9
4	2·8	12	8·4	20	14·0	28	19·6
5	3·5	13	9·1	21	14·7	29	20·3
6	4·2	14	9·8	22	15·4	30	21·0
7	4·9	15	10·5	23	16·1	31	21·7
8	5·6	16	11·2	24	16·8	32	22·4

TABLES REQUIRED IN WATER ANALYSIS. TABLE X.—*continued.*

Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
33	23·1	78	54·6	123	86·1	168	117·6
34	23·8	79	55·3	124	86·8	169	118·3
35	24·5	80	56·0	125	87·5	170	119·0
36	25·2	81	56·7	126	88·2	171	119·7
37	25·9	82	57·4	127	88·9	172	120·4
38	26·6	83	58·1	128	89·6	173	121·1
39	27·3	84	58·8	129	90·3	174	121·8
40	28·0	85	59·5	130	91·0	175	122·5
41	28·7	86	60·2	131	91·7	176	123·2
42	29·4	87	60·9	132	92·4	177	123·9
43	30·1	88	61·6	133	93·1	178	124·6
44	30·8	89	62·3	134	93·8	179	125·3
45	31·5	90	63·0	135	94·5	180	126·0
46	32·2	91	63·7	136	95·2	181	126·7
47	32·9	92	64·4	137	95·9	182	127·4
48	33·6	93	65·1	138	96·6	183	128·1
49	34·3	94	65·8	139	97·3	184	128·8
50	35·0	95	66·5	140	98·0	185	129·5
51	35·7	96	67·2	141	98·7	186	130·2
52	36·4	97	67·9	142	99·4	187	130·9
53	37·1	98	68·6	143	100·1	188	131·6
54	37·8	99	69·3	144	100·8	189	132·3
55	38·5	100	70·0	145	101·5	190	133·0
56	39·2	101	70·7	146	102·2	191	133·7
57	39·9	102	71·4	147	102·9	192	134·4
58	40·6	103	72·1	148	103·6	193	135·1
59	41·3	104	72·8	149	104·3	194	135·8
60	42·0	105	73·5	150	105·0	195	136·5
61	42·7	106	74·2	151	105·7	196	137·2
62	43·4	107	74·9	152	106·4	197	137·9
63	44·1	108	75·6	153	107·1	198	138·6
64	44·8	109	76·3	154	107·8	199	139·3
65	45·5	110	77·0	155	108·5	200	140·0
66	46·2	111	77·7	156	109·2	201	140·7
67	46·9	112	78·4	157	109·9	202	141·4
68	47·6	113	79·1	158	110·6	203	142·1
69	48·3	114	79·8	159	111·3	204	142·8
70	49·0	115	80·5	160	112·0	205	143·5
71	49·7	116	81·2	161	112·7	206	144·2
72	50·4	117	81·9	162	113·4	207	144·9
73	51·1	118	82·6	163	114·1	208	145·6
74	51·8	119	83·3	164	114·8	209	146·3
75	52·5	120	84·0	165	115·5	210	147·0
76	53·2	121	84·7	166	116·2	211	147·7
77	53·9	122	85·4	167	116·9	212	148·4

TABLES REQUIRED IN WATER ANALYSIS. TABLE X.—*continued.*

Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
213	149·1	223	156·1	233	163·1	243	170·1
214	149·8	224	156·8	234	163·8	244	170·8
215	150·5	225	157·5	235	164·5	245	171·5
216	151·2	226	158·2	236	165·2	246	172·2
217	151·9	227	158·9	237	165·9	247	172·9
218	152·6	228	159·6	238	166·6	248	173·6
219	153·3	229	160·3	239	167·3	249	174·3
220	154·0	230	161·0	240	168·0	250	175·0
221	154·7	231	161·7	241	168·7		
222	155·4	232	162·4	242	169·4		

CALCULATION OF THE RESULTS OF WATER ANALYSIS.

Substance estimated.	Quantity of Water taken.	To get Grains per gallon.	Logarithms.
N as HNO_3 (Crum)	250 c.c.	*c.c. of NO at N.T.P. × ·1751 = N	$\bar{1}$·248 2861
NH_3 (copper zinc)	100 c.c.	grams of NH_3 × 575·73 = N	2·760 2200
,, (aluminium)	50 c.c.	,, × 1151·46 = N	3·061 2500
O absorbed	250 c.c. + 10 c.c. $K_2Mn_2O_8$	$0{\cdot}28\left(\frac{S-W}{S}\right)$†	
,,	250 c.c. + 15 c.c. $K_2Mn_2O_8$	$0{\cdot}28\left(\frac{1{\cdot}58-W}{S}\right)$†	
Total solids	250 c.c.	grams × 280	2·447 1580

* Or thus. Let v = vol. of NO obtained from 250 c.c. of the water.
b = height of Bar.
w = tension of aqueous vapour at the observed temperature (see Table I.).

Then N in grains per gallon $= v \times \frac{\cdot 0012507}{760(1+\cdot 00367\ t)} \times (b-w) \times 140.$

For logs. of $\frac{\cdot 0012507}{760(1+\cdot 00367\ t)}$ for different values of t see Table II.

Log. 140 = 2·146 1280.

† S = c.c. of $Na_2S_2O_3$ corresponding to 10 c.c. $K_2Mn_2O_8$.
W = ,, ,, required by the water under examination.

THRESH'S SOLUTION OF STARCH AND POTASSIUM IODIDE.

This solution is used by Dr Thresh in his method for the determination of nitrites in potable waters.*

It is made as follows:—

Starch in powder	0·2 gram.
Caustic potash	1 „
Potassium iodide	2 grams.
Water	200 c.c.

Add the starch to 10 c.c. of water, and when uniformly diffused add the caustic potash. Dissolve without the aid of heat and add the remainder of the water and the potassium iodide. Strain or filter. This solution keeps for months without appreciable change.

A useful test may be carried out as follows:—

Shake the sample of water vigorously in a bottle only partially filled, to saturate with air: pour 50 c.c. into a Nessler cylinder and add 1 c.c. of the above solution and then 1 c.c. of dilute sulphuric acid (1 vol. acid to 3 vols. water). Stir. Assuming the temperature to be about 60° F., if a dark blue tint develops instantaneously the water contains more than 0·1 part per 100,000 of nitrous nitrogen. If it becomes blue in a few seconds it contains about 0·01 per 100,000. If it requires more than ten seconds to develop it contains less than this amount.

EXAMPLE OF THE DETERMINATION OF NITRATES BY CRUM'S METHOD.

0·5 gram of a substance containing nitrate of soda treated by Crum's method gave 13·6 c.c. of NO measured at 8° C. and 737 mm. Bar. To find the percentages of nitrogen and of sodium nitrate present.

	Bar. 737 mm.
Tension of aqueous vapour at 8° C. =	8 mm. by Table I.
Pressure on the dry gas	729 mm.

NO contains half its volume of nitrogen.

$$\text{Weight of nitrogen} = \frac{v}{2}\,(b-w)\times\frac{\cdot 0012507}{760\,(1+\cdot 00367t)}$$

$$= 6\cdot 8\times 729\times\frac{\cdot 0012507}{760\,(1+\cdot 00367\times 8)}$$

log. 6·8 = 0·83251

„ 729 = 2·86273

log. fraction—by Table II. $= \bar{6}\cdot 20379$

$\bar{3}\cdot 89903 = 0\cdot 007926$ gram Nitrogen in 0·5 gram

·007926 × 200 = 1·59% nitrogen

and by logs. 1·59 nitrogen = 9·65% sodium nitrate.

* *Chemical News*, 1890, vol. 62, p. 204.

Water and Sewage Examination Results.

(British Association Report, 1899.)

The Committee appointed by the British Association to devise a uniform system of recording the results of the chemical and bacteriological examination of water and sewage reported as follows :—

It is desirable that results of analysis should be expressed in *parts per* 100,000, except in the case of dissolved gases, when these should be stated as c.c. of gas at 0° C. and 760 mm. in 1 litre of water. This method of recording results is in accordance with that suggested by the Committee appointed in 1887 to confer with the Committee of the American Association for the advancement of science, with a view to forming a uniform system of recording the results of water analysis.

It is suggested that in the case of all nitrogen compounds the results be expressed as parts of nitrogen per 100,000, including the ammonia expelled on boiling with alkaline permanganate, which should be termed *albuminoid nitrogen*. The nitrogen will therefore be returned as:

(1) Ammoniacal nitrogen from free and saline ammonia.
(2) Nitrous nitrogen from nitrites.
(3) Nitric nitrogen from nitrates.
(4) Organic nitrogen (either by Kjeldahl or by combustion, but the process used should be stated).
(5) Albuminoid nitrogen.

The total nitrogen of all kinds will be the sum of the first four determinations.

The Committee are of opinion that the percentage of nitrogen oxidized—that is, the ratio of (2) and (3) to (1) and (4)—gives sometimes a useful measure of the stage of purification of a particular sample. The purification effected by a process will be measured by the amount of oxidized nitrogen as compared with the total amount of nitrogen existing in the crude sewage.

In raw sewage and in effluents containing suspended matter, it is also desirable to determine how much of the organic nitrogen is present in the suspended matter.

In sampling, the Committee suggest that the bottles should be filled nearly completely with the liquid, only a small air-bubble being allowed to remain in the neck of the bottle. The time at which a sample is drawn, as well as the time at which its analysis is begun, should be noted. An effluent should be drawn to correspond as nearly as possible with the original sewage, and both it and the sewage should be taken in quantities proportional to the rate of flow when that varies (*e.g.* in the emptying of a filter-bed).

In order to avoid the multiplication of analyses, the attendant at a sewage works (or any other person who draws the samples) might be provided with sets of twelve or twenty-four stoppered

quarter-Winchester bottles, one of which should be filled every hour or every two hours, and on the label of each bottle the rate of flow at the time should be written. When the bottles reach the laboratory, quantities would be taken from each proportional to these rates of flow and mixed together, by which means a fair average sample for the twenty-four hours would be obtained.

The Committee were unable to suggest a method of reporting bacterial results, including incubator tests, that would be likely to be acceptable to all workers.

The Committee consisted of Professor W. Ramsay (chairman), Sir W. Crookes, Professors F. Clowes, P. F. Frankland, and R. Boyce, and Dr Rideal (secretary).

Standards for Sewage Effluents.

Various standards of purity or limits of impurity of sewage effluents have from time to time been put forward. These, however, have been superseded by the recommendations given in the Fifth Report of the Royal Commission on Sewage Disposal.* In this the Commissioners report that:—"The experiments which we have already made show that the mere estimation of the amount of organic matter in an effluent does not, by itself, afford a sufficiently reliable index as to the effect which that effluent will have on any stream into which it may be discharged" (par. 320). Further on we read: "According to our present knowledge, an effluent can best be judged by ascertaining, first, the amount of suspended matter which it contains, and, second, the rate at which the effluent, after the removal of the suspended solids, takes up oxygen from water."

The recommendations given are as follows:—

"For the guidance of local authorities, we may provisionally state that an effluent would generally be satisfactory if it complied with the following conditions:—

(1) That it should not contain more than 3 parts per 100,000 of suspended matter; and

(2) That, after being filtered through paper, it should not absorb more than

(*a*) 0·5 part by weight per 100,000 of dissolved or atmospheric oxygen in 24 hours.

(*b*) 1·0 part by weight per 100,000 of dissolved or atmospheric oxygen in 48 hours; or

(*c*) 1·5 part by weight per 100,000 of dissolved or atmospheric oxygen in 5 days."

* Cd. 4278. Issued in 1908.

TABLE GIVING THE AMOUNTS OF DISSOLVED OXYGEN IN DISTILLED WATER AT VARIOUS TEMPERATURES (BAR. 760 mm.).*

Temperature °C.	Oxygen (parts per 100,000).	Temperature °C.	Oxygen (parts per 100,000).	Temperature °C.	Oxygen (parts per 100,000).
0	1·42	11	1·09	21	0·88
1	1·39	12	1·07	22	0·87
2	1·36	13	1·04	23	0·85
3	1·32	14	1·02	24	0·84
4	1·28	15	1·00	25	0·82
5	1·24	16	0·98	26	0·81
6	1·22	17	0·96	27	0·80
7	1·19	18	0·94	28	0·80
8	1·17	19	0·92	29	0·79
9	1·14	20	0·90	30	0·78
10	1·11				

* Calculated from Roscoe and Lunt's table (*Trans. Chem. Soc.*, 1889, 569) for temperatures from 5°–30° C. The values given for 0°–4° are based on determinations by Winkler's process.

Tables required in the Analysis of Beer.

Spirit Indication, with corresponding Degrees of Gravity lost in Malt Worts, by the "Distillation Process."

Degrees of Spirit Indication.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	0·0	0·3	0·6	0·9	1·2	1·5	1·8	2·1	2·4	2·7
1	3·0	3·3	3·7	4·1	4·4	4·8	5·1	5·5	5·9	6·2
2	6·6	7·0	7·4	7·8	8·2	8·6	9·0	9·4	9·8	10·2
3	10·7	11·1	11·5	12·0	12·4	12·9	13·3	13·8	14·2	14·7
4	15·1	15·5	16·0	16·4	16·8	17·3	17·7	18·2	18·6	19·1
5	19·5	19·9	20·4	20·9	21·3	21·8	22·2	22·7	23·1	23·6
6	24·1	24·6	25·0	25·5	26·0	26·4	26·9	27·4	27·8	28·3
7	28·8	29·2	29·7	30·2	30·7	31·2	31·7	32·2	32·7	33·2
8	33·7	34·3	34·8	35·4	35·9	36·5	37·0	37·5	38·0	38·6
9	39·1	39·7	40·2	40·7	41·2	41·7	42·2	42·7	43·2	43·7
10	44·2	44·7	45·1	45·6	46·0	46·5	47·0	47·5	48·0	48·5
11	49·0	49·6	50·1	50·6	51·2	51·7	52·2	52·7	53·3	53·8
12	54·3	54·9	55·4	55·9	56·4	56·9	57·4	57·9	58·4	58·9
13	59·4	60·0	60·5	61·1	61·6	62·2	62·7	63·3	63·8	64·3
14	64·8	65·4	65·9	66·5	67·1	67·6	68·2	68·7	69·3	69·9
15	70·5	71·1	71·7	72·3	72·9	73·5	74·1	74·7	75·3	75·9

Spirit Indication, with corresponding Degrees of Gravity lost in Malt Worts, by the "Evaporation Process."

Degrees of Spirit Indication.	0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	...	·3	·7	1·0	1·4	1·7	2·1	2·4	2·8	3·1
1	3·5	3·8	4·2	4·6	5·0	5·4	5·8	6·2	6·6	7·0
2	7·4	7·8	8·2	8·7	9·1	9·5	9·9	10·3	10·7	11·1
3	11·5	11·9	12·4	12·8	13·2	13·6	14·0	14·4	14·8	15·3
4	15·8	16·2	16·6	17·0	17·4	17·9	18·4	18·8	19·3	19·8
5	20·3	20·7	21·2	21·6	22·1	22·5	23·0	23·4	23·9	24·3
6	24·8	25·2	25·6	26·1	26·6	27·0	27·5	28·0	28·5	29·0
7	29·5	30·0	30·4	30·9	31·3	31·8	32·3	32·8	33·3	33·8
8	34·3	34·9	35·5	36·0	36·6	37·1	37·7	38·3	38·8	39·4
9	40·0	40·5	41·0	41·5	42·0	42·5	43·0	43·5	44·0	44·4
10	44·9	45·4	46·0	46·5	47·1	47·6	48·2	48·7	49·3	49·8
11	50·3	50·9	51·4	51·9	52·5	53·0	53·5	54·0	54·5	55·0
12	55·6	56·2	56·7	57·3	57·8	58·3	58·9	59·4	59·9	60·5
13	61·0	61·6	62·1	62·7	63·2	63·8	64·3	64·9	65·4	66·0
14	66·5	67·0	67·6	68·1	68·7	69·2	69·8	70·4	70·9	71·4
15	72·0									

Table for ascertaining the Value of the Acetic Acid.

Corresponding Degrees of "Spirit Indication."

Excess per cent. of Acetic Acid in the Beer.	·00	·01	·02	·03	·04	·05	·06	·07	·08	·09
·0	...	·02	·04	·06	·07	·08	·09	·11	·12	·13
·1	·14	·15	·17	·18	·19	·21	·22	·23	·24	·26
·2	·27	·28	·29	·31	·32	·33	·34	·35	·37	·38
·3	·39	·40	·42	·43	·44	·46	·47	·48	·49	·51
·4	·52	·53	·55	·56	·57	·59	·60	·61	·62	·64
·5	·65	·66	·67	·69	·70	·71	·72	·73	·75	·76
·6	·77	·78	·80	·81	·82	·84	·85	·86	·87	·89
·7	·90	·91	·93	·94	·95	·97	·98	·99	1·10	1·02
·8	1·03	1·04	1·05	1·07	1·08	1·09	1·10	1·11	1·13	1·14
·9	1·15	1·16	1·18	1·19	1·21	1·22	1·23	1·25	1·26	1·28
1·0	1·29	1·31	1·33	1·35	1·36	1·37	1·38	1·40	1·41	1·42

Table for Salt in Beer.

*Salt in Grains per Gallon, corresponding to c.c. of Decinormal $AgNO_3$.**
25 c.c. of Beer to be employed.

c.c. $\frac{N}{10}$ $AgNO_3$	Grains NaCl per gallon.	c.c. $\frac{N}{10}$ $AgNO_3$	Grains NaCl per gallon.	c.c. $\frac{N}{10}$ $AgNO_3$	Grains NaCl per gallon.
0·1	1·64	2·2	36·04	4·2	68·80
0·2	3·28	2·3	37·67	4·3	70·43
0·3	4·91	2·4	39·31	4·4	72·07
0·4	6·55	2·5	40·95	4·5	73·71
0·5	8·19	2·6	42·59	4·6	75·35
0·6	9·83	2·7	44·23	4·7	76·99
0·7	11·47	2·8	45·86	4·8	78·62
0·8	13·10	2·9	47·50	4·9	80·26
0·9	14·74	3·0	49·14	5·0	81·90
1·0	16·38	3·1	50·78	5·1	83·54
1·1	18·02	3·2	52·42	5·2	85·18
1·2	19·66	3·3	54·05	5·3	86·81
1·3	21·29	3·4	55·69	5·4	88·45
1·4	22·93	3·5	57·33	5·5	90·09
1·5	24·57	3·6	58·97	5·6	91·73
1·6	26·21	3·7	60·61	5·7	93·37
1·7	27·85	3·8	62·24	5·8	95·00
1·8	29·48	3·9	63·88	5·9	96·64
1·9	31·12	4·0	65·52	6·0	98·28
2·0	32·76	4·1	67·16	6·1	99·92
2·1	34·40				

Note.—The above table is useful in giving the amount of NaCl that may be present, calculated from the combined chlorine found. To obtain the actual amount of sodium chloride, the sodium present must also be determined.

* 1 c.c. = 0·00585 gm. NaCl.

Examples of the determination of "original gravity" of beer.

I. By the Distillation Process.

Experimental data:—

Sp. gr. of the spirit distillate at 60° F. . . .	989·40
" " extract residue " . . .	1018·76
Acidity (calculated as acetic acid) . . .	0·15%

Then 1000 − 989·40 = ...	10·60	spirit indication	
0·15 − 0·10* = 0·05, which by Table (p. 99) shows	0·08	"	"
Total	10·68	"	"

By Table (p. 98) 10·68 spirit indication = 47·0 + (·8 × ·5)
= 47·40 degrees of gravity lost

Sp. gr. of extract residue = 1018·76

1066·16 original gravity.

Or, omit taking the extract gravity and take that of the beer itself, whence a theoretical extract gravity can be found as follows:—

Experimental data:—

Sp. gr. of the beer at 60° F.	1008·36
" " spirit distillate . . .	989·40
Acidity "	0·15%

1008·36
989·40

18·96

(less) ·20 (a constant †)

18·76 + 1000 = 1018·76, the extract gravity deduced.

Degrees of gravity lost (found as above) 47·40

1066·16 original gravity.

II. By the Evaporation Process.

Experimental data:—

Sp. gr. of the beer at 60° F. .	1009·70
" " extract residue " . . .	1019·55
Acidity (calculated as acetic acid) . .	0·26%

Then 1019·55 − 1009·70	= 9·85	spirit indication	
0·26 − ·10 = 0·16, which by Table (p. 99) shows	0·22	"	"
Total	10·07	"	"

* Graham, Hofmann and Redwood calculated that the *normal acidity* of beer is 0·10 per cent. expressed as acetic acid. In the calculation above we have to take into consideration only the acidity in excess of the normal amount.

† Representing the gain in density by condensation when the constituents of beer are mixed together: the gain in density varies from 0·15 to 0·35, the average being 0·2.

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By Table (p. 98) 10·07 spirit indication = 44·9 + (·7 × ·5)
= 45·25 degrees of gravity lost
sp. gr. of extract residue = 1019·55

1064·80 original gravity.

Note.—The above examples are taken from J. A. Nettleton's *Original Gravity*.

Blunt's Modification of Tabarie's Formula.

Tabarie's formula for indirectly determining alcohol in beer and wine from the sp. gr. of the original sample and of the boiled sample made up to the volume taken at the same temperature is

$$\text{sp. gr. of alcohol boiled away} = \frac{S}{S_b}$$

where S = sp. gr. of original liquid
S_b = „ boiled „ or "extract."

Blunt has shown* that a more correct result is obtained by using the formula

$$\text{sp. gr. of alcohol boiled away} = 1 - (S_b - S)$$
$$= 1 + S - S_b$$

This is fully confirmed by Hehner, who found "that in all cases the results obtained by subtraction are closer to those obtained by distillation than are those by Tabarie's formula, and the results are better the greater the alcoholic strength." †

Specific Rotatory Power.

The specific rotatory power of an optically active substance in solution may be defined as the angle through which a plane polarized ray of light of definite refrangibility is rotated by a column one decimetre in length of a solution containing 1 gram of the substance in 1 c.c.

If the rotation is observed through a tube l decimetres in length, and the solution contains c grams of substances in 100 c.c., then, if α be the angle of rotation, the "specific rotatory power" is given by the formula

$$[\alpha] = \frac{\alpha . 100}{l . c.}$$

The ray used and the temperature of the liquid are generally added, thus $[\alpha]_D^{20} = 66{\cdot}6°$ means that the specific rotatory power for ray D ‡ at the temperature of 20° C. is 66·6°.

The specific rotatory power (or "specific rotation") of liquid carbon compounds is given by the formula

$$[\alpha] = \frac{\alpha}{l . d.}$$

Where l is the length of the observation tube in decimetres, d is the sp. gr. of the liquid referred to water at 4° C. as standard, in which case d expresses the weight in grams of 1 c.c.

* *Analyst*, 1891, 16, p. 221. † *Ibid.*, p. 223. ‡ Sodium flame.

In this country observations are commonly made at a temperature of 60° F., but on the Continent 20° C. is the "normal temperature" of observation. With many substances, however, a difference of 4·4° C. causes but little difference in the readings.

Molecular Rotation.—This term is applied to the product of the molecular weight (M) and specific rotation of a body divided by 100, and is represented by the symbol [M].

$$[M] = \frac{M}{100}[\alpha]$$

The divisor 100 is used simply to avoid the use of inconveniently large numbers. [M] expresses the rotation which would result if each c.c. of the solution contained 1 gram-molecule of the active substance and the length of the liquid column were 1 mm.

Multirotation.—Freshly prepared solutions of a number of the sugars show a rotatory power different from that of the same solution on standing, undergoing either an increase or decrease until finally a constant value is reached. This phenomenon is termed *multirotation* or *mutarotation.*

Originally the term bi-rotation was used, as the observation was made that a dextrose solution when freshly prepared gave about twice the reading of the same solution after standing.

At the ordinary temperature a period of from six to twenty-four hours is usually required, but by boiling the transformation to the stable form is completed in a few minutes.* Dextrose, lactose, and maltose show this behaviour, maltose giving with a freshly made solution a *lower* reading than that observed after standing for some hours. Sucrose does not show this effect.

Observations are usually made with a polarimeter, such as Laurent's half-shadow instrument, for which homogeneous light, generally a sodium flame, is required; or with a Soleil-Ventzke-Scheibler Colour Saccharimeter, which is adapted for use with white light illumination from oil or gas lamps; or with a modern Half-shadow Saccharimeter,† in which the field of view is divided into two surfaces, each of which alternately becomes perfectly dark as the analyser is rotated, the point sought, and at which the reading is taken, being that at which the two surfaces show exactly the same degree of illumination or partial shadow. White light is used.

Specific rotatory power as determined by the (more or less obsolete) Soleil-Ventzke-Scheibler Colour Saccharimeter is indicated by $[\alpha]_j$, where j is the *transition tint* (*i.e.* from the blue to the red), and is the ray complementary to the medium yellow or *jaune moyen*—hence the j. This *jaune moyen* ray is the true medium

* The same result is also attained by adding a few drops of strong ammonia before making up the volume of the solution.

† In the latest type of polarimeter, the optical field is divided into 3 parts instead of 2, as in the half-shadow instruments. Such instruments are more accurate, the equality of the field being capable of a more delicate adjustment. These "have properly displaced the colour instruments completely: the part of these in saccharimetry has been played, and for good" (Dr. Schönrock).

yellow of the solar spectrum; its wave-length is 0·0005608 millimetres.* The Ventzke scale is such that 100 divisions equal the amount of rotation caused by a "normal sugar solution," 200 mm. in length, at 17·5° C. Ventzke proposed a method of preparing this solution which was intended to render the use of a balance unnecessary. He defined the normal sugar solution as a solution of pure sugar in water which should have at 17·5° C. the sp. gr. of 1·100, water at 17·5° being unity. To determine then the polarizing sugar of any substance, it would simply be necessary to prepare a solution of it having this density as shown by a hydrometer. But this method was soon abandoned, because the salts in the cane-sugars to be investigated have a density different from that of sugar itself, and hence cause erroneous results. As, however, the 100 point of many saccharimeters had already been fixed by aid of the normal sugar solution of 1·1 sp. gr., and as it was desirable not to change the scale once introduced, the concentration of the Ventzke normal solution at 17·5° was then determined, and it was found that 100 c.c. of such a solution contained 26·048 grams of sugar: thus the *normal weight* should be 26·048 grams.

The above remarks apply only to the original Ventzke instruments. Since 1900 the *normal weight* has been altered to 26·0 grams, and the *normal sugar solution* is prepared as follows:—

26 grams of chemically pure dry sugar are dissolved in water at 20° C. in a flask graduated to contain 100 true c.c. The solution is made up to the mark, well mixed, filtered if necessary, and polarized in a 200-mm. tube at 20° C. The reading should be 100 scale-divisions, and each scale-division indicates 0·26 gram of sucrose.

FACTORS FOR THE CONVERSION OF $[\alpha]_D$ INTO $[\alpha]_j$ AND *vice versa*.

To convert $[\alpha]_D$ into $[\alpha]_j$, multiply by 1·111 (log. 0·04571) or *add one-ninth.*

To convert $[\alpha]_j$ into $[\alpha]_D$, multiply by 0·9 (log. $\bar{1}$·95429) or *subtract one-tenth.*

Thus if $[\alpha]_D = 202°$, then $[\alpha]_j = 202 + 22·4 = 224·4°$.
$[\alpha]_j = 57°$, then $[\alpha]_D = 57 - 5·7 = 51·3°$.

[Landolt gives $[\alpha]_j = \dfrac{24·5}{21·72}[\alpha]_D = 1·128\,[\alpha]_D$.

$$[\alpha]_D = \frac{21·72}{24·5}[\alpha]_j = 0·887\,[\alpha]_j].$$

In the Soleil-Ventzke-Scheibler Saccharimeter 100 scale-divisions equal 38·43° for ray j, or

$$1 \text{ scale-division} = 0·3843°\ \alpha_j \text{ (log. } \bar{1}·58467).$$

* The wave-length of D is 589 $\mu\mu$.

[According to Dr Schönrock*

100° Ventzke = 34·68° for D at 17·5°C.

or 1° „ = 0·3468° „ „

The number 0·3468 is called the *factor of reduction.*

"Landolt has actually found in the observation of a cane-sugar solution in a Schmidt and Haensch half-shadow saccharimeter, with a gas lamp, that a rotation of 100° V. corresponds to the rotation of 34·65° ± 0·05° for sodium light. But if it is required accurately to measure the rotation of a sugar solution for sodium light, this must be done in a polarimeter actually illuminated by sodium light." *]

The values representing specific rotation vary directly as the sp. gr. divisor (D) used. Thus, if 150° be the specific rotation of maltose for $[\alpha]_{j\,3·86}$ (that is, on the basis of the 3·86 divisor) the specific rotation where the divisor 3·93 is used will be $\frac{150 \times 3·93}{3·86} = 152·7°$.

The number of grams per 100 c.c. of a solution of a carbohydrate of which the sp. gr. (water = 1000) is known is found by dividing the sp. gr. minus 1000 by a constant given in the subjoined table. This constant is usually denoted by D.

TABLE SHOWING THE SPECIFIC ROTATORY POWERS OF THE PRINCIPAL CARBOHYDRATES IN 10 PER CENT. SOLUTION AT 20° C. (= 68° F.).

Substance.	Formula.	Divisor to get grams per 100 c.c.†	Specific rotatory power (absolute.)		Specific rotatory power reduced to the common divisor 3·86.	
		D	$[\alpha]_D$	$[\alpha]_j$	$[\alpha]_{D3·86}$	$[\alpha]_{j3·86}$
Sucrose	$C_{12}H_{22}O_{11}$	3·85	+ 66·5°	+ 73·8°	+ 66·6°	+ 74·0°
Dextrose (d-Glucose)	$C_6H_{12}O_6$	3·85	+ 52·7°	+ 58·6°	+ 52·8°	+ 58·7°
Laevulose (d-Fructose)	„	3·85	− 93·8°	−104·2°	− 94·0°	−104·5°
Invert Sugar	$C_6H_{12}O_6$ + $C_6H_{12}O_6$	3·85	−20·55°	− 22·8°	− 20·6°	− 22·9°
Maltose	$C_{12}H_{22}O_{11}$	3·93	+138°	+153·3°	+135·5°	+150·6°
Dextrin	$(C_6H_{10}O_5)_n$	3·95	+200°	+222·2°	+195·4°	+217·1°
Lactose (cryst.)	$C_{12}H_{22}O_{11} \cdot H_2O$	3·71	+ 52·5°	+ 58·3°	...	...
Lactose (anhyd.)	$C_{12}H_{22}O_{11}$	3·91	+ 55·3°	+ 61·4°	...	...

Note.—At the meeting of the International Commission for unifying methods of sugar analysis, held in Paris in 1900, the normal temperature of +20° C. was adopted and all measuring vessels are required to be graduated in true c.c. at this temperature.

* Landolt's *Optical Rotation of Organic Substances*, Part IV.

† For a complete series of correct divisors for various concentrations, the valuable papers by Brown, Morris and Millar in the *Journ. Chem. Soc.*, 1897, should be consulted. According to J. Heron, the common divisor 3·86 gives total solids correctly only in those cases where the sp. gr. of the solution lies between 1036 and 1040. For solutions containing more than 12 grams of solids per 100 c.c. the divisor 3·85 gives closer results.

The following values are given in Landolt's work already referred to:—

Substance.	Formula.	Strength of solution in grams per 100 c.c.	$[\alpha]_D^{20}$
Cane-sugar	$C_{12}H_{22}O_{11}$	10	$+\ 66^\circ{\cdot}5$
Glucose (Dextrose)	$C_6H_{12}O_6$*	1 – 15	+ 52·8
Fructose (Laevulose)	,,	10	– 98
Invert Sugar	$C_6H_{12}O_6 + C_6H_{12}O_6$	10	– 20·1
Maltose	$C_{12}H_{22}O_{11}$†	10	+137·5
Lactose	$C_{12}H_{22}O_{11}.\ H_2O$	1 – 36	+ 52·5
Galactose	$C_6H_{12}O_6$	1 – 15 or 20	+ 81
Raffinose	$C_{18}H_{32}O_{16}.\ 5H_2O$	10	+104·5

SOLEIL-VENTZKE-SCHEIBLER SACCHARIMETER
200-MM. TUBE USED: TRANSITION TINT.

1 gram in 100 c.c. of	Scale-divisions of deviation at 20° C.‡	
	For absolute divisors.	For 3·86 divisor.
Cane-sugar . .	+ 3·84§	+ 3·85
Dextrose . .	+ 3·05	+ 3·08
Laevulose . .	– 5·42	– 5·44
Invert sugar . .	– 1·19	– 1·18
Maltose . . .	+ 7·98	+ 7·84
Lactose (cryst.) .	+ 3·03	...
,, (anhyd.) .	+ 3·20	...
Dextrin . . .	+11·56	+11·30
Gallisin . . .	...	+ 4·85

	Multiplier.	Logarithm.
To convert $C_{12}H_{22}O_{11}$ into $C_{12}H_{24}O_{12}$	$\frac{360{\cdot}192}{342{\cdot}176} = 1{\cdot}053$	0·02228
$C_{12}H_{24}O_{12}$,, $C_{12}H_{22}O_{11}$	$\frac{342{\cdot}176}{360{\cdot}192} = 0{\cdot}95$	$\bar{1}{\cdot}97772$
$C_{12}H_{20}O_{10}$,, $C_{12}H_{24}O_{12}$	$\frac{360{\cdot}192}{324{\cdot}16} = 1{\cdot}111$ or add one-ninth	0·04577
$C_{12}H_{24}O_{12}$,, $C_{12}H_{20}O_{10}$	$\frac{324{\cdot}16}{360{\cdot}192} = 0{\cdot}9$ or deduct one-tenth	$\bar{1}{\cdot}95423$

* When crystallized $C_6H_{12}O_6.\ H_2O$. † When crystallized $C_{12}H_{22}O_{11}.H_2O$.
‡ The number of scale-divisions are obtained by dividing the $[\alpha]_D$ in each case by 19·215 (log. 1·28364).
§ When inverted this becomes –1·25.

The following examples show the methods employed in solving problems connected with this subject.

Ex. I. To find a formula for calculating the amount of cane-sugar present in a mixture of cane-sugar and dextrose when the specific rotatory power (ray j) before and after inversion are known.

Let R_b be the specific rotatory power before inversion
R_a be the specific rotatory power after inversion
and let x be the percentage of cane-sugar present.
Then $100 - x$ is the percentage of dextrose present.

$$\text{Hence } 100\,R_b = \;\;73{\cdot}8x + (100 - x)\,58{\cdot}6$$
$$\text{and } \;\;100\,R_a = -24{\cdot}0x + (100 - x)\,58{\cdot}6$$
$$\therefore \quad 100\,(R_b - R_a) = 97{\cdot}8x.$$
$$x = \frac{R_b - R_a}{{\cdot}978}.$$

Similarly when we have given the scale-degrees (D) before and after inversion, the 200-mm. tube being used—

$$\text{Grams of cane-sugar per 100 c.c. of solution} = \frac{D_b - D_a}{5{\cdot}09}.$$

Ex. II. Determination of cane-sugar in mixtures of cane- and invert-sugar only.

The method now universally adopted is Herzfeld's modification of Clerget's process.* It is carried out as follows:—Dissolve the normal weight (26·048 † grams) of the sample to be examined in water and make up to 100 c.c., decolorizing and filtering if necessary, and polarize at 20° C. Transfer 50 c.c. of this solution to a 100-c.c. flask, add 5 c.c. strong (38%) hydrochloric acid and about 20 c.c. of water. Well shake the flask and immerse in a bath of water at the temperature of 70° C., at the same time putting a thermometer in the flask: when the temperature of the sugar solution has reached 68° – 70° C., which it should do in five minutes, the flask is kept in the water-bath at this temperature for five minutes longer, then taken out, cooled down quickly to the normal temperature, diluted with water to 100 c.c., polarized at 20° C., and the reading multiplied by two on account of the dilution of the liquid.

Herzfeld found that pure cane-sugar treated as above showed a change of rotation on a Soleil-Ventzke-Scheibler Saccharimeter of 132·66 divisions at 20° C. Hence—

$$\text{Cane-sugar \%} = \frac{100\,(\text{direct—inverted reading})^*}{132{\cdot}66}.$$

But, since the algebraical difference here becomes the *sum of the two readings without regard to sign*, and $100/132{\cdot}66 = 0{\cdot}7539$

$$\text{Cane-sugar \%} = 0{\cdot}7539 \times (\text{sum of readings})$$
$$[\log.\ 0{\cdot}7539 = \bar{1}{\cdot}87729].$$

* This method is only applicable when other sugars, inulins, starches, and glucosides, which are also inverted by acids, are not present. When such bodies are present, hydrolysis may be effected by the use of invertase. † Now 26·0 grams.

If, instead of 20° C., the readings before and after inversion are made at t° C.,

$$\text{Cane-sugar } \% = \frac{100\,(\text{direct—inverted reading})}{142{\cdot}66 - \frac{t}{2}}.$$

Ex. III. Determination of dextrose and maltose from the cupric reducing power and optical activity (or "opticity") of a solution before and after fermentation.

As an example we may take a commercial "Glucose," which gave the following results:—

Cupric reduction before fermentation	78·85 %
" after "	6·62 "
	72·23
Opticity before fermentation	49·98 $[\alpha]_D$.
" after "	11·24 "
	38·74

By fermentation dextrose and maltose are removed, and the differences between the cupric reductions and between the opticities before and after fermentation give measures of the amounts of the two sugars present. Hence, if D and M be the percentages of dextrose and maltose present respectively, we have (taking 62 as the K of maltose):—

$$62\text{ M} + 100\ \text{D} = 7223 \text{ (i)}$$
$$138\text{ M} + 52{\cdot}7\ \text{D} = 3874 \text{ (ii)}$$

$$\begin{array}{rr} \text{(i)} \times 138. & 8556\text{ M} + 13800\text{ D} = 996774 \\ \text{(ii)} \times\ 62. & 8556\text{ M} + \ 3267\text{ D} = 240188 \\ \hline & 10533\text{ D} = 756586 \end{array}$$

$$\text{D} = \frac{756586}{10533} = 71{\cdot}83$$

$$\text{From (i)} \quad 62\text{ M} = 7223 - 7183 = 40.$$

$$\text{M} = \frac{40}{62} = 0{\cdot}65.$$

Result—Dextrose 71·83 %
Maltose 0·65 "

Polarimeter Readings.—Reduction of Minutes to Decimals of a Degree.

Minutes	Decimal equivalent.	Minutes.	Decimal equivalent.	Minutes.	Decimal equivalent.	Minutes.	Decimal equivalent.
1	·017°	16	·267°	31	·517°	46	·767°
2	·033	17	·283	32	·533	47	·783
3	·05	18	·3	33	·55	48	·8
4	·067	19	·317	34	·567	49	·817
5	·083	20	·333	35	·583	50	·833
6	·1	21	·35	36	·6	51	·85
7	·117	22	·367	37	·617	52	·867
8	·133	23	·383	38	·633	53	·883
9	·15	24	·4	39	·65	54	·9
10	·167	25	·417	40	·667	55	·917
11	·183	26	·433	41	·683	56	·933
12	·2	27	·45	42	·7	57	·95
13	·217	28	·467	43	·717	58	·967
14	·233	29	·483	44	·733	59	·983
15	·25	30	·5	45	·75		

POLARIMETER READINGS.—REDUCTION OF MINUTES TO OF A DEGREE.

Minutes	Decimal equivalent.	Minutes.	Decimal equivalent.	Minutes.	Decimal equivalent.	Minu
1	°·017	16	°·267	31	°·517	46
2	·033	17	·283	32	·533	47
3	·05	18	·3	33	·55	48
4	·067	19	·317	34	·567	49
5	·083	20	·333	35	·583	50
6	·1	21	·35	36	·6	51
7	·117	22	·367	37	·617	52
8	·133	23	·383	38	·633	53
9	·15	24	·4	39	·65	54
10	·167	25	·417	40	·667	55
11	·183	26	·433	41	·683	56
12	·2	27	·45	42	·7	57
13	·217	28	·467	43	·717	58
14	·233	29	·483	44	·733	59
15	·25	30	·5	45	·75	

CUPRIC OXIDE REDUCING POWERS OF THE CARBOHYDRATES.

Definition.—"Dextrose being the type of reducing bodies and the substance for which the amount of cupric oxide reduced was first determined, I use it as the standard to which to refer all other reducing carbohydrates or mixtures of reducing with non-reducing ones. I take the cupric oxide reducing power (or 'cupric reducing power') of a body or mixture to be the amount of cupric oxide, calculated as dextrose, which 100 parts reduce: it is designated by the letter K."—(*O'Sullivan*).

Briefly, we may define "K" as the specific cupric reducing power of a substance referred to dextrose as standard (100). The divisor is often added: thus $K_{3\cdot86} = 25$ means that the cupric reducing power of the substance is one-fourth that of dextrose when the solid matter is determined by the 3·86 divisor.

Preparation of Fehling's Solution for Gravimetric Determinations.—Dissolve 34·64 grams of pure recrystallized copper sulphate in distilled water and make up the volume to 500 c.c. Then dissolve 173 grams Rochelle salt and 65 grams anhydrous sodium hydroxide in separate beakers, mix the solutions, and make up the volume with distilled water to 500 c.c. These two solutions are kept in separate bottles and are mixed in equal volumes, to form Fehling's solution, immediately before use.

Method of making a determination of cupric reducing power.—Fifty c.c. of the freshly mixed Fehling's solution are placed in a beaker of about 250 c.c. capacity, and having a diameter of 7·5 cm. (= 3 inches). This is placed in a boiling water-bath, and when the solution has attained the temperature of the water, the accurately weighed or measured volume of the sugar solution is added, and the whole made up to 100 c.c. with boiling distilled water. The beaker, which is covered with a clock glass, is then returned to the water-bath and the heating continued for exactly twelve minutes. The precipitated cuprous oxide is now rapidly filtered off through a Soxhlet tube, washed first with hot water, then with alcohol and ether, and finally dried. When dry, the cuprous oxide is reduced to metallic copper by gently heating in a stream of hydrogen, and weighed; or it may be oxidized in a stream of oxygen and weighed as CuO. Sometimes the Cu_2O is weighed as such, after being dried in a water oven (see O'Sullivan and Stern, *Jour. Chem. Soc.*, 1896, p. 1692).

As spontaneous reduction of Fehling's solution invariably takes place, the amount of this must be carefully determined for every fresh batch of the solution and allowed for in each determination of cupric reducing power. It usually amounts to 0·002 to 0·003 gram CuO per 50 c.c. of Fehling's solution used.

It is of great importance, in making the above determination, that *an amount of the reducing sugar is taken that will give a weight of CuO lying between* 0·15 *and* 0·35 *gram.*

It must be carefully borne in mind that the values given in the following tables are correct only when the preparation of the Fehling's solution, and the manner of carrying out the determination of cupric reducing power conform exactly with the directions given on p. 109. It has been shown that the amount and nature of the alkali in Fehling's solution exercises a great influence on the quantity of copper reduced by a given weight of maltose or of the starch-transformation products; but with dextrose and laevulose the influence is far less. Glendinning has proved that an equivalent amount of potassium hydroxide may be substituted for the sodium compound without causing any alteration in the reducing power. In the case of dextrose and laevulose the variant which has the greatest influence is the state of dilution of the Fehling's solution. When the dilution is greater than that prescribed in the standard method, the reducing power is appreciably lower, and the greater the dilution the greater the difference.

The weights of the principal kinds of sugar which, it is generally assumed, will reduce 10 c.c. of Fehling's solution are as follows :—

10 c.c. Fehling's solution
=0·0500 gram of dextrose, laevulose or invert sugar.
=0·0475 „ „ sucrose (after inversion)
=0·0678 „ „ lactose
=0·0807 „ „ maltose

Rules to find the values of "K" when referred to different divisors.

When the true divisor is used to determine grams of sugar per 100 c.c., the K so obtained is called *absolute*. Frequently, however, $K_{3\cdot86}$—that is, the relative cupric reducing power when the divisor 3·86 is used to get grams of sugar per 100 c.c.—is required. Thus, 1·367 grams CuO = 1 gram of absolute maltose, then for 1 gram of 3·86 maltose we should have

$$1\cdot367 \times \frac{3\cdot86}{3\cdot93} = 1\cdot343 \text{ gram CuO}.$$

Let the true divisor to get grams per 100 c.c. be M, then

$$\text{K absolute} = \frac{K_{3\cdot86} \times M}{3\cdot86}.$$

Fehling's solution may not give correct results after keeping (say a few months), even when the tartrate component solution remains perfectly clear and apparently undecomposed. Decidedly *low* results have been obtained by the use of such a solution.

For *gallisin* $K_{3\cdot86} = 42$.

1 gram = 1·01 gram CuO (approximately).

FACTORS FOR THE DETERMINATION OF CARBOHYDRATES FROM THEIR CUPRIC OXIDE REDUCING POWERS.

Sugar.	Factor.	Logarithm.	One gram of	grams.	Logarithm.
Dextrose, laevulose or invert sugar ($C_6H_{12}O_6$)	Cu × 0·5676	$\bar{1}$·75408	Dextrose, laevulose or invert sugar $C_6H_{12}O_6$	= 1·762 Cu	0·24592
"	Cu_2O × 0·5042	$\bar{1}$·70260	"	= 1·983 Cu_2O	0·29740
"	CuO × 0·4535	$\bar{1}$·65658	"	= 2·205 CuO	0·34342
Sucrose, $C_{12}H_{22}O_{11}$ (after inversion)	Cu × 0·5392	$\bar{1}$·73178	Sucrose, $C_{12}H_{22}O_{11}$ (after inversion)	= 1·854 Cu	0·26822
"	Cu_2O × 0·4790	$\bar{1}$·68030	"	= 2·088 Cu_2O	0·31970
"	CuO × 0·4308	$\bar{1}$·63428	"	= 2·321 CuO	0·36572
Maltose, $C_{12}H_{22}O_{11}$	Cu × 0·9155	$\bar{1}$·96166	Maltose, $C_{12}H_{22}O_{11}$	= 1·092 Cu	0·03834
"	Cu_2O × 0·8132	$\bar{1}$·91018	"	= 1·230 Cu_2O	0·08982
"	CuO × 0·7314	$\bar{1}$·86416	"	= 1·367 CuO	0·13584
Starch or Dextrin (after hydrolysis)	Cu × 0·5109	$\bar{1}$·70831	Starch or Dextrin (after hydrolysis)	= 1·958 Cu	0·29169
"	Cu_2O × 0·4538	$\bar{1}$·65683	"	= 2·204 Cu_2O	0·34317
"	CuO × 0·4081	$\bar{1}$·61081	"	= 2·450 CuO	0·38919
Lactose* (anhydr.), ($C_{12}H_{22}O_{11}$)	Cu × 0·7240	$\bar{1}$·85973	Lactose (anhydr.), $C_{12}H_{22}O_{11}$	= 1·381 Cu	0·14027
"	Cu_2O × 0·6431	$\bar{1}$·80825	"	= 1·555 Cu_2O	0·19175
"	CuO × 0·5784	$\bar{1}$·76223	"	= 1·729 CuO	0·23777
Lactose* (cryst.), $C_{12}H_{22}O_{11}$, H_2O	Cu × 0·7621	$\bar{1}$·88201	Lactose (cryst.), $C_{12}H_{22}O_{11}$, H_2O	= 1·312 Cu	0·11799
"	Cu_2O × 0·6769	$\bar{1}$·83053	"	= 1·477 Cu_2O	0·16947
"	CuO × 0·6088	$\bar{1}$·78451	"	= 1·642 CuO	0·21549

Ex.—From a solution of 0·1 gram of sucrose, which has been inverted, 0·198 gram of CuO has been obtained. Then sucrose present—

$$= 0·198 \times ·4308 = 0·085298 = 85·3\%.$$

From the above we get the following values of "K":—

Dextrose, K = 100	Invert sugar, K = 100	Lactose (anhydr.) K = 78·4
Laevulose, " = 100	Maltose, " = 62	" (cryst.) " = 74·5

* For lactose (cryst.) E. W. T. Jones in 1893 (private communication to the author) found with an exceedingly pure sample the CuO factor 0·6087 = 0·5783 for the anhydrous sugar. Rodewald and Tollens's average factor is 0·5785. I have adopted the mean of these two values.

ALCOHOL TABLE.

Sp. gr. at 60° F.	Per cent. of Alcohol by weight.	Per cent. of Alcohol by volume.	Per cent. *under* Proof.	Sp. gr. at 60° F.	Per cent. of Alcohol by weight.	Per cent. of Alcohol by volume.	Per cent. *under* Proof.
1·0000	0·00	0·00	100·00	·9775	15·25	18·78	67·10
·9995	0·26	0·33	99·42	·9770	15·67	19·28	66·20
·9990	0·53	0·66	98·84	·9765	16·08	19·78	65·34
·9985	0·79	0·99	98·26	·9760	16·46	20·24	64·53
·9980	1·06	1·34	97·66	·9755	16·85	20·71	63·72
·9975	1·37	1·73	96·97	·9750	17·25	21·19	62·87
·9970	1·69	2·12	96·29	·9745	17·67	21·69	62·00
·9965	2·00	2·51	95·60	·9740	18·08	22·18	61·13
·9960	2·28	2·86	95·00	·9735	18·46	22·64	60·32
·9955	2·56	3·21	94·40	·9730	18·85	23·10	59·52
·9950	2·83	3·55	93·78	·9725	19·25	23·58	58·67
·9945	3·12	3·90	93·16	·9720	19·67	24·08	57·80
·9940	3·41	4·27	92·50	·9715	20·08	24·58	56·93
·9935	3·71	4·63	91·87	·9710	20·50	25·07	56·06
·9930	4·00	5·00	91·23	·9705	20·92	25·57	55·20
·9925	4·31	5·39	90·55	·9700	21·31	26·04	54·37
·9920	4·62	5·78	89·87	·9695	21·69	26·49	53·57
·9915	4·94	6·17	89·20	·9690	22·08	26·95	52·77
·9910	5·25	6·55	88·50	·9685	22·46	27·40	51·98
·9905	5·56	6·94	87·84	·9680	22·85	27·86	51·18
·9900	5·87	7·32	87·16	·9675	23·23	28·31	50·38
·9895	6·21	7·74	86·43	·9670	23·62	28·77	49·60
·9890	6·57	8·18	85·65	·9665	24·00	29·22	48·80
·9885	6·93	8·63	84·88	·9660	24·38	29·67	48·00
·9880	7·27	9·04	84·15	·9655	24·77	30·13	47·20
·9875	7·60	9·45	83·43	·9650	25·14	30·57	46·44
·9870	7·93	9·86	82·70	·9645	25·50	30·98	45·70
·9865	8·29	10·30	81·96	·9640	25·86	31·40	44·97
·9860	8·64	10·73	81·20	·9635	26·20	31·80	44·27
·9855	9·00	11·17	80·42	·9630	26·53	32·19	43·60
·9850	9·36	11·61	79·65	·9625	26·87	32·58	42·90
·9845	9·71	12·05	78·90	·9620	27·21	32·98	42·20
·9840	10·08	12·49	78·10	·9615	27·57	33·39	41·47
·9835	10·46	12·96	77·30	·9610	27·93	33·81	40·74
·9830	10·85	13·43	76·46	·9605	28·25	34·18	40·10
·9825	11·23	13·90	75·64	·9600	28·56	34·54	39·47
·9820	11·62	14·37	74·82	·9595	28·87	34·90	38·84
·9815	12·00	14·84	74·00	·9590	29·20	35·28	38·18
·9810	12·38	15·30	73·18	·9585	29·53	35·66	37·50
·9805	12·77	15·77	72·36	·9580	29·87	36·04	36·83
·9800	13·15	16·24	71·54	·9575	30·17	36·39	36·23
·9795	13·54	16·70	70·73	·9570	30·44	36·70	35·68
·9790	13·92	17·17	69·90	·9565	30·72	37·02	35·13
·9785	14·36	17·70	68·97	·9560	31·00	37·34	34·57
·9780	14·82	18·25	68·00	·9555	31·31	37·69	33·95

ALCOHOL TABLE—*continued.*

Sp. gr. at 60° F.	Per cent. of Alcohol by weight.	Per cent. of Alcohol by volume.	Per cent. *under* Proof.	Sp. gr. at 60° F.	Per cent. of Alcohol by weight.	Per cent. of Alcohol by volume.	Per cent. *under* Proof.
·9550	31·62	38·04	33·32	·9325	43·48	51·07	10·50
·9545	31·94	38·40	32·70	·9320	43·71	51·32	10·05
·9540	32·25	38·75	32·08	·9315	43·95	51·58	9·60
·9535	32·56	39·11	31·46	·9310	44·18	51·82	9·20
·9530	32·87	39·47	30·84	·9305	44·41	52·06	8·77
·9525	33·18	39·81	30·24	·9300	44·64	52·29	8·36
·9520	33·47	40·14	29·66	·9295	44·86	52·53	7·94
·9515	33·76	40·47	29·08	·9290	45·09	52·77	7·52
·9510	34·05	40·79	28·52	·9285	45·32	53·01	7·10
·9505	34·29	41·05	28·06	·9280	45·55	53·24	6·70
·9500	34·52	41·32	27·60	·9275	45·77	53·48	6·27
·9495	34·76	41·58	27·13	·9270	46·00	53·72	5·86
·9490	35·00	41·84	26·67	·9265	46·23	53·95	5·45
·9485	35·25	42·12	26·20	·9260	46·46	54·19	5·03
·9480	35·50	42·40	25·70	·9255	46·68	54·43	4·62
·9475	35·75	42·67	25·22	·9250	46·91	54·66	4·20
·9470	36·00	42·95	24·74	·9245	47·14	54·90	3·80
·9465	36·28	43·26	24·20	·9240	47·36	55·13	3·38
·9460	36·56	43·56	23·66	·9235	47·59	55·37	2·97
·9455	36·83	43·87	23·12	·9230	47·82	55·60	2·56
·9450	37·11	44·18	22·58	·9225	48·05	55·83	2·15
·9445	37·39	44·49	22·04	·9220	48·27	56·07	1·74
·9440	37·67	44·79	21·50	·9215	48·50	56·30	1·33
·9435	37·94	45·10	20·96	·9210	48·73	56·54	0·92
·9430	38·22	45·41	20·43	·9205	48·96	56·77	0·50
·9425	38·50	45·71	19·89	·9200	49·16	56·98	0·14
·9420	38·78	46·02	19·36	·9198	49·24	57·06	Proof
·9415	39·05	46·32	18·83	·9195	49·39	57·20	0·25
·9410	39·30	46·59	18·36	·9190	49·64	57·45	0·68
·9405	39·55	46·86	17·88	·9185	49·86	57·69	1·10
·9400	39·80	47·13	17·40	·9180	50·09	57·92	1·51
·9395	40·05	47·40	16·93	·9175	50·30	58·14	1·89
·9390	40·30	47·67	16·46	·9170	50·52	58·36	2·28
·9385	40·55	47·94	15·98	·9165	50·74	58·58	2·66
·9380	40·80	48·21	15·50	·9160	50·96	58·80	3·05
·9375	41·05	48·48	15·04	·9155	51·17	59·01	3·41
·9370	41·30	48·75	14·57	·9150	51·38	59·22	3·78
·9365	41·55	49·02	14·10	·9145	51·58	59·43	4·14
·9360	41·80	49·29	13·63	·9140	51·79	59·63	4·50
·9355	42·05	49·55	13·16	·9135	52·00	59·84	4·87
·9350	42·29	49·81	12·70	·9130	52·23	60·07	5·27
·9345	42·52	50·06	12·27	·9125	52·45	60·30	5·67
·9340	42·76	50·31	11·82	·9120	52·68	60·52	6·07
·9335	43·00	50·57	11·38	·9115	52·91	60·74	6·47
·9330	43·24	50·82	10·94	·9110	53·13	60·97	6·86

ALCOHOL TABLE—*continued.*

Sp. gr. at 60° F.	Per cent. of Alcohol by weight.	Per cent. of Alcohol by volume.	Per cent. *over* Proof.	Sp. gr. at 60° F.	Per cent. of Alcohol by weight.	Per cent. of Alcohol by volume.	Per cent. *over* Proof.
·9105	53·35	61·19	7·23	·8880	63·26	70·77	24·02
·9100	53·57	61·40	7·61	·8875	63·48	70·97	24·37
·9095	53·78	61·62	7·99	·8870	63·70	71·17	24·73
·9090	54·00	61·84	8·36	·8865	63·91	71·38	25·09
·9085	54·24	62·07	8·78	·8860	64·13	71·58	25·44
·9080	54·48	62·31	9·20	·8855	64·35	71·78	25·79
·9075	54·71	62·55	9·62	·8850	64·57	71·98	26·15
·9070	54·95	62·79	10·03	·8845	64·78	72·18	26·50
·9065	55·18	63·02	10·44	·8840	65·00	72·38	26·85
·9060	55·41	63·24	10·84	·8835	65·21	72·58	27·19
·9055	55·64	63·46	11·24	·8830	65·42	72·77	27·52
·9050	55·86	63·69	11·64	·8825	65·63	72·96	27·85
·9045	56·09	63·91	12·03	·8820	65·83	73·15	28·19
·9040	56·32	64·14	12·41	·8815	66·04	73·34	28·52
·9035	56·55	64·36	12·80	·8810	66·26	73·54	28·87
·9030	56·77	64·58	13·18	·8805	66·48	73·73	29·22
·9025	57·00	64·80	13·57	·8800	66·70	73·93	29·57
·9020	57·22	65·01	13·92	·8795	66·91	74·13	29·92
·9015	57·42	65·21	14·27	·8790	67·13	74·33	30·26
·9010	57·63	65·41	14·62	·8785	67·33	74·52	30·59
·9005	57·83	65·61	14·97	·8780	67·54	74·70	30·92
·9000	58·05	65·81	15·33	·8775	67·75	74·89	31·25
·8995	58·27	66·03	15·72	·8770	67·96	75·08	31·58
·8990	58·50	66·25	16·11	·8765	68·17	75·27	31·90
·8985	58·73	66·47	16·49	·8760	68·38	75·45	32·23
·8980	58·95	66·69	16·88	·8755	68·58	75·64	32·56
·8975	59·17	66·90	17·25	·8750	68·79	75·83	32·89
·8970	59·39	67·11	17·61	·8745	69·00	76·01	33·21
·8965	59·61	67·32	17·98	·8740	69·21	76·20	33·54
·8960	59·83	67·53	18·34	·8735	69·42	76·39	33·86
·8955	60·04	67·73	18·70	·8730	69·63	76·57	34·19
·8950	60·26	67·93	19·05	·8725	69·83	76·76	34·51
·8945	60·46	68·13	19·39	·8720	70·04	76·94	34·84
·8940	60·67	68·33	19·74	·8715	70·24	77·12	35·14
·8935	60·88	68·52	20·08	·8710	70·44	77·29	35·45
·8930	61·08	68·72	20·42	·8705	70·64	77·46	35·76
·8925	61·29	68·91	20·77	·8700	70·84	77·64	36·07
·8920	61·50	69·11	21·11	·8695	71·04	77·82	36·37
·8915	61·71	69·30	21·45	·8690	71·25	78·00	36·69
·8910	61·92	69·50	21·79	·8685	71·46	78·18	37·01
·8905	62·14	69·71	22·16	·8680	71·67	78·36	37·33
·8900	62·36	69·92	22·53	·8675	71·88	78·55	37·65
·8895	62·59	70·14	22·91	·8670	72·09	78·73	37·98
·8890	62·82	70·35	23·29	·8665	72·30	78·93	38·32
·8885	63·04	70·57	23·66	·8660	72·52	79·12	38·65

ALCOHOL TABLE—*continued.*

gr. 0° F.	Per cent. of Alcohol by weight.	Per cent. of Alcohol by volume.	Per cent. *over* Proof.	Sp. gr. at 60° F.	Per cent. of Alcohol by weight.	Per cent. of Alcohol by volume.	Per cent. *over* Proof.
655	72·74	79·31	38·99	·8430	82·15	87·24	52·90
650	72·96	79·50	39·32	·8425	82·35	87·40	53·16
645	73·17	79·68	39·64	·8420	82·54	87·55	53·43
640	73·38	79·86	39·96	·8415	82·73	87·70	53·70
635	73·58	80·04	40·27	·8410	82·92	87·85	53·96
630	73·79	80·22	40·60	·8405	83·12	88·00	54·23
625	74·00	80·40	40·91	·8400	83·31	88·15	54·50
620	74·23	80·60	41·26	·8395	83·50	88·31	54·75
615	74·45	80·80	41·61	·8390	83·69	88·46	55·02
610	74·68	81·00	41·96	·8385	83·88	88·61	55·28
605	74·91	81·20	42·31	·8380	84·08	88·76	55·55
600	75·14	81·40	42·66	·8375	84·28	88·92	55·83
595	75·36	81·60	43·00	·8370	84·48	89·08	56·10
590	75·59	81·80	43·35	·8365	84·68	89·24	56·38
585	75·82	82·00	43·70	·8360	84·88	89·39	56·66
580	76·04	82·19	44·04	·8355	85·08	89·55	56·93
575	76·25	82·37	44·35	·8350	85·27	89·70	57·20
570	76·46	82·54	44·66	·8345	85·46	89·84	57·45
565	76·67	82·72	44·97	·8340	85·65	89·99	57·71
560	76·88	82·90	45·28	·8335	85·85	90·14	57·97
555	77·08	83·07	45·60	·8330	86·04	90·29	58·23
550	77·29	83·25	45·90	·8325	86·23	90·43	58·48
545	77·50	83·43	46·20	·8320	86·42	90·58	58·74
540	77·71	83·60	46·51	·8315	86·62	90·73	59·00
535	77·92	83·78	46·82	·8310	86·81	90·88	59·26
530	78·12	83·94	47·11	·8305	87·00	91·02	59·51
525	78·32	84·11	47·40	·8300	87·19	91·17	59·77
520	78·52	84·27	47·70	·8295	87·38	91·31	60·02
515	78·72	84·44	47·98	·8290	87·58	91·46	60·28
510	78·92	84·60	48·27	·8285	87·77	91·60	60·53
505	79·12	84·77	48·56	·8280	87·96	91·75	60·79
500	79·32	84·93	48·84	·8275	88·16	91·90	61·05
495	79·52	85·10	49·13	·8270	88·36	92·05	61·32
490	79·72	85·26	49·38	·8265	88·56	92·21	61·60
485	79·92	85·42	49·67	·8260	88·76	92·36	61·86
480	80·13	85·59	50·00	·8255	88·96	92·51	62·12
475	80·33	85·77	50·31	·8250	89·16	92·66	62·38
470	80·54	85·94	50·61	·8245	89·35	92·80	62·63
465	80·75	86·11	50·91	·8240	89·54	92·94	62·88
460	80·96	86·28	51·21	·8235	89·73	93·09	63·13
455	81·16	86·45	51·50	·8230	89·92	93·23	63·38
450	81·36	86·61	51·78	·8225	90·11	93·36	63·62
445	81·56	86·77	52·06	·8220	90·29	93·49	63·84
440	81·76	86·93	52·34	·8215	90·46	93·62	64·06
435	81·96	87·09	52·62	·8210	90·64	93·75	64·30

ALCOHOL TABLE—*continued.*

Sp. gr. at 60° F.	Per cent. of Alcohol by weight.	Per cent. of Alcohol by volume.	Per cent. over Proof.	Sp. gr. at 60° F.	Per cent. of Alcohol by weight.	Per cent. of Alcohol by volume.	Per cent. over Proof.
·8205	90·82	93·87	64·51	·8065	95·86	97·39	70·67
·8200	91·00	94·00	64·74	·8060	96·03	97·51	70·88
·8195	91·18	94·13	64·96	·8055	96·20	97·62	71·07
·8190	91·36	94·26	65·18	·8050	96·37	97·73	71·26
·8185	91·54	94·38	65·40	·8045	96·53	97·83	71·45
·8180	91·71	94·51	65·62	·8040	96·70	97·94	71·64
·8175	91·89	94·64	65·85	·8035	96·87	98·05	71·83
·8170	92·07	94·76	66·07	·8030	97·03	98·16	72·02
·8165	92·26	94·90	66·30	·8025	97·20	98·27	72·20
·8160	92·44	95·03	66·53	·8020	97·37	98·37	72·40
·8155	92·63	95·16	66·76	·8015	97·53	98·48	72·58
·8150	92·81	95·29	67·00	·8010	97·70	98·59	72·77
·8145	93·00	95·42	67·23	·8005	97·87	98·69	72·95
·8140	93·18	95·55	67·46	·8000	98·03	98·80	73·14
·8135	93·37	95·69	67·70	·7995	98·19	98·89	73·30
·8130	93·55	95·82	67·92	·7990	98·34	98·98	73·47
·8125	93·74	95·95	68·15	·7985	98·50	99·07	73·64
·8120	93·92	96·08	68·38	·7980	98·66	99·16	73·81
·8115	94·10	96·20	68·60	·7975	98·81	99·26	73·97
·8110	94·28	96·32	68·80	·7970	98·97	99·35	74·14
·8105	94·45	96·43	69·00	·7965	99·13	99·45	74·31
·8100	94·62	96·55	69·20	·7960	99·29	99·55	74·50
·8095	94·80	96·67	69·40	·7955	99·45	99·65	74·66
·8090	94·97	96·78	69·61	·7950	99·61	99·75	74·83
·8085	95·14	96·90	69·82	·7945	99·78	99·86	75·01
·8080	95·32	97·02	70·03	·7940	99·94	99·96	75·18
·8075	95·50	97·15	70·25		Absolute	Alcohol	
·8070	95·68	97·27	70·46	·7938	100·00	100·00	75·25

In "The Sale of Food and Drugs Act Amendment Act, 1879," section 6, it is enacted that Brandy, Whisky, or Rum may be reduced to 25° U.P. and Gin to 35° U.P.

25° U.P. = 0·9473 sp. gr., 42·78 per cent. alcohol by volume, 35·85 per cent. alcohol by weight.

35° U.P. = 0·9564 sp. gr., 37·08 per cent. alcohol by volume, 30·78 per cent. alcohol by weight.

"Rectified spirit" (B.P. 1898) is alcohol of sp. gr. 0·8340. It contains 90 per cent. of alcohol by volume, 85·65 per cent. of alcohol by weight; 57·7° O.P.

"Proof Spirit" is defined by statute (58 Geo. III. c. 28) as "that which at a temperature of 51° F. weighs exactly twelve-thirteenths of an equal measure of distilled water." The sp. gr. of proof spirit at 51° F. is 0·92308 (water at 51° F. = 1). At 60° F./60° F. its sp. gr.

is 0·91984, and it contains 57·06 per cent. of alcohol by volume, 49·24 per cent. by weight.

By the "obscuration" of spirits is meant the difference between the apparent alcoholic strength, as shown by the hydrometer, and the true strength found after distillation.

Simple rules for finding the percentages of added water in the case of diluted spirits.

I. Brandy, Whisky, or Rum (25° U. P. allowed).

Let a sample be N° U. P.

Therefore in 100 volumes we have N volumes of water, and (100 – N) volumes of proof-spirit.

Let x be the percentage of water by volume added to spirit of 25° U. P. to produce a sample N° U. P. Then equating amounts of water we have—

$$(100-x)\frac{25}{100}+x=N.$$

$$25-\frac{x}{4}+x=N.$$

$$\frac{3}{4}x=N-25.$$

$$x=\frac{4(N-25)}{3}.$$

Hence we have the following rule:—

To get percentage of added water by volume in the case of diluted brandy, whisky, or rum, increase the excess of degrees U. P. above 25 by one-third.

II. Gin (35° U. P. allowed).

Reasoning exactly as in I., we have—

$$(100-x_1)\frac{35}{100}+x_1=N_1.$$

$$35-\frac{7}{20}x_1+x_1=N_1.$$

$$\frac{13}{20}x_1=N_1-35.$$

$$x_1=\frac{20}{13}(N_1-35).$$

$$x_1=1{\cdot}54(N_1-35).$$

Hence the rule:—

To get percentage of added water by volume in diluted gin, multiply the excess of degrees U. P above 35 by 1·54.

*** The above rules I owe to Mr E. W. T. Jones, who discovered them empirically and used them simply for checking results obtained by the usual method of calculation from the percentage of alcohol present. The proofs I have given above established the accuracy of Rule I., and gave the correct factor 1·54 in Rule II. in place of the $1\frac{1}{2}$ previously used for checking.—*A. E. J.*

Correction of Specific Gravity of Dilute Alcohol for Temperature.

Specific Gravity.	1° Fah.	1° C.	Specific Gravity.	1° Fah.	1° C.
·794–·864	0·00046	0·00083	·965– ·966	0·00026	0·00047
·864–·889	45	81	·966– ·967	25	45
·889–·902	44	79	·967– ·968	24	43
·902–·912	43	77	·968– ·969	23	41
·912–·921	42	76	·969– ·970	22	40
·921–·928	41	74	·970– ·971	21	38
·928–·935	40	72	·971– ·973	20	36
·935–·940	39	70	·973– ·974	19	34
·940–·943	38	68	·974– ·975	18	32
·943–·946	37	67	·975– ·976	17	31
·946–·949	36	65	·976– ·977	16	29
·949–·951	35	63	·977– ·978	15	27
·951–·953	34	61	·978– ·980	14	25
·953–·955	33	59	·980– ·981	13	23
·955–·957	32	58	·981– ·983	12	22
·957–·959	31	56	·983– ·985	11	20
·959–·961	30	54	·985– ·987	10	18
·961–·962	29	52	·987– ·990	·00009	16
·962–·963	28	50	·990– ·995	8	14
·963–·965	27	49	·995–1·000	7	13

Rule.—To obtain correct sp. gr. at 60° Fah. (=15·5° C.), multiply the factor given in the table opposite to the observed sp. gr. by the difference in temperature, and *add* if the recorded temperature is *above* 60° F., or *subtract* if it is *below* 60°.

Ex.—The sp. gr. at 60° Fah. of dilute alcohol of sp. gr. 0·952 at 64° Fah. is $0·952+(0·00034\times 4)=0·95336$.

Various Methods of stating Alcoholic Strengths.

Based on Squibb's absolute alcohol of sp. gr. 0·7935,

Proof spirit containing 49·2 °/₀ of this alcohol, and having a sp. gr. of 0·9198,

and using c.c. to indicate the volume of 1 gram of water at 60° F., we have the formulæ given below.

Let S = sp. gr. at 60°/60° F.

°/₀ = grams of absolute alcohol per 100 grams.

v/v = c.c. absolute alcohol per 100 c.c.

w/v = grams of absolute alcohol per 100 c.c.

P = c.c. proof spirit per 100 c.c.

then

$$°/_\circ = \frac{v/v \times ·7935}{S} = \frac{w/v}{S} = \frac{P \times ·4525}{S}$$

$$v/v = °/_\circ \times 1·262\ S = 1·262\ w/v = 0·5703\ P$$

$$w/v = °/_\circ \times S \qquad = ·7935\ v/v = 0·4525\ P$$

$$P = °/_\circ \times 2·21\ S = 1·753\ v/v = 2·21\ w/v$$

grains per fluid ounce $= w/v \times 4·3756$.

ALCOHOL CALCULATIONS.

Ex. 1. To find the quantity of water which must be added to spirit of 25° O.P. to reduce it to 20° U.P.—

100 volumes of spirit at 25° O.P. contain as much alcohol as 125 volumes of proof spirit.
100 volumes of spirit at 20° U.P. contain as much alcohol as 80 volumes of proof spirit.
Hence, 125 volumes of proof spirit are equivalent to 100 volumes of spirit of 25° O.P.

1 volume of proof spirit is equivalent to $\frac{100}{125}$ volumes of spirit of 25° O.P.

80 volumes of proof spirit are equivalent to $\frac{100 \times 80}{125} = 64$ volumes of spirit of 25° O.P.;

that is, 100 volumes of spirit of 20° U.P. can be made by diluting 64 volumes of spirit of 25° O.P. with water.

Suppose, for example, 10 gallons at 20° U.P. are required, we take 6·4 gallons at 25° O.P., or 6 gallons 1 quart 1½ pints, and dilute with water to 10 gallons.

Ex. 2. To find the quantity of water which must be added to spirit of 60° O.P. to reduce it to 30° O.P.

100 volumes of spirit at 60° O.P. are equivalent to 160 volumes of proof spirit.
100 volumes of spirit at 30° O.P. are equivalent to 130 volumes of proof spirit.
Hence 160 volumes of proof spirit are equivalent to 100 volumes of spirit of 60° O.P.—

1 volume of proof spirit is equivalent to $\frac{100}{160}$ volumes of spirit of 60° O.P.

130 volumes of proof spirit are equivalent to $\frac{130 \times 100}{160} =$ 81¼ volumes of spirit of 60° O.P.;

that is, 100 volumes of spirit of 30° O.P. can be made by diluting 81¼ volumes of spirit of 60° O.P. with water.

Thus if 20 gallons are required we must take 16¼ gallons of the strong spirit and dilute with water to 20 gallons.

TABLE SHOWING THE AMOUNTS TO BE *subtracted* FROM THE VALUES GIVEN IN THE PHOSPHATE TABLE SO THAT THEY MAY BE IN ACCORDANCE WITH THE INTERNATIONAL ATOMIC WEIGHTS OF 1912.

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
10·0	0·03	0·02	0·02	...
15·0	0·05	0·03	0·03	0·008
20·0	0·07	0·05	0·03	0·011
25·0	0·08	0·06	0·04	0·013
30·0	0·09	0·07	0·05	0·016
35·0	0·11	0·08	0·06	0·019
40·0	0·13	0·09	0·07	0·021
45·0	0·15	0·10	0·07	0·025
50·0	0·16	0·12	0·08	0·027
55·0	0·18	0·13	0·09	0·029
60·0	0·19	0·13	0·10	0·033
65·0	0·21	0·14	0·11	0·035
70·0	0·23	0·15	0·12	0·038

Ex. 1. 2 grams of a sample of Superphosphate gave 0·3770 gram $Mg_2P_2O_7$.

From the Table 37·70 $= 52·64$ $Ca_3P_2O_8$
Correction (mean of ·11 and ·13) $=$ ·12

2)52·52

26·26% $Ca_3P_2O_8$

Ex. 2. 1 gram of a Phosphate gave 0·5500 gram $Mg_2P_2O_7$.

From the Table 55·00 $Mg_2P_2O_7 =$ 35·18 $P_2O_5 =$ 76·80 $Ca_3P_2O_8$.
Correction (to be subtracted) ·09 ·18

35·09% $P_2O_5 =$ 76·62 $Ca_3P_2O_8$.

Table for Phosphates.

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
0·1	0·14	0·09	0·06	0·028	4·1	5·73	3·66	2·62	1·145
·2	0·28	0·18	0·13	0·056	·2	5·87	3·75	2·69	1·173
·3	0·42	0·27	0·19	0·084	·3	6·00	3·84	2·75	1·201
·4	0·56	0·36	0·26	0·112	·4	6·14	3·93	2·82	1·229
·5	0·70	0·45	0·32	0·140	·5	6·28	4·01	2·88	1·257
·6	0·84	0·54	0·38	0·168	·6	6·42	4·10	2·94	1·285
·7	0·98	0·62	0·45	0·196	·7	6·56	4·19	3·01	1·313
·8	1·12	0·71	0·51	0·223	·8	6·70	4·28	3·07	1·341
·9	1·26	0·80	0·58	0·251	·9	6·84	4·37	3·14	1·369
1·0	1·40	0·89	0·64	0·279	5·0	6·98	4·46	3·20	1·396
·1	1·54	0·98	0·70	0·307	·1	7·12	4·55	3·26	1·424
·2	1·68	1·07	0·77	0·335	·2	7·26	4·64	3·33	1·452
·3	1·82	1·16	0·83	0·363	·3	7·40	4·73	3·39	1·480
·4	1·96	1·25	0·90	0·391	·4	7·54	4·82	3·45	1·508
·5	2·09	1·34	0·96	0·419	·5	7·68	4·91	3·52	1·536
·6	2·23	1·43	1·02	0·447	·6	7·82	5·00	3·58	1·564
·7	2·37	1·52	1·09	0·475	·7	7·96	5·08	3·65	1·592
·8	2·51	1·61	1·15	0·503	·8	8·10	5·17	3·71	1·620
·9	2·65	1·70	1·22	0·531	·9	8·24	5·26	3·77	1·648
2·0	2·79	1·78	1·28	0·559	6·0	8·38	5·35	3·84	1·676
·1	2·93	1·87	1·34	0·587	·1	8·52	5·44	3·90	1·704
·2	3·07	1·96	1·41	0·614	·2	8·66	5·53	3·97	1·732
·3	3·21	2·05	1·47	0·642	·3	8·80	5·62	4·03	1·760
·4	3·35	2·14	1·54	0·670	·4	8·94	5·71	4·09	1·787
·5	3·49	2·23	1·60	0·698	·5	9·08	5·80	4·16	1·815
·6	3·63	2·32	1·66	0·726	·6	9·22	5·89	4·22	1·843
·7	3·77	2·41	1·73	0·754	·7	9·36	5·98	4·29	1·871
·8	3·91	2·50	1·79	0·782	·8	9·50	6·07	4·35	1·899
·9	4·05	2·59	1·86	0·810	·9	9·64	6·15	4·41	1·927
3·0	4·19	2·68	1·92	0·838	7·0	9·77	6·24	4·48	1·955
·1	4·33	2·77	1·98	0·866	·1	9·91	6·33	4·54	1·983
·2	4·47	2·85	2·05	0·894	·2	10·05	6·42	4·61	2·011
·3	4·61	2·94	2·11	0·922	·3	10·19	6·51	4·67	2·039
·4	4·75	3·03	2·18	0·950	·4	10·33	6·60	4·73	2·067
·5	4·89	3·12	2·24	0·978	·5	10·47	6·69	4·80	2·095
·6	5·03	3·21	2·30	1·006	·6	10·61	6·78	4·86	2·123
·7	5·17	3·30	2·37	1·033	·7	10·75	6·87	4·93	2·151
·8	5·31	3·39	2·43	1·061	·8	10·89	6·96	4·99	2·178
·9	5·45	3·48	2·50	1·089	·9	11·03	7·05	5·05	2·206
4·0	5·59	3·57	2·56	1·117	8·0	11·17	7·14	5·12	2·234

$Mg_2P_2O_7$	·01	·02	·03	·04	·05	·06	·07	·08	·09
$Ca_3P_2O_8$	·01	·03	·04	·06	·07	·08	·10	·11	·13
CaP_2O_6	·01	·02	·03	·04	·05	·05	·06	·07	·08
P_2O_5	·01	·01	·02	·03	·03	·04	·05	·05	·06
P_2	·003	·006	·008	·011	·014	·017	·020	·022	·025

TABLE FOR PHOSPHATES—*continued.*

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
8·1	11·31	7·22	5·18	2·262	12·7	17·73	11·33	8·12	3·547
·2	11·45	7·31	5·25	2·290	·8	17·87	11·42	8·19	3·575
·3	11·59	7·40	5·31	2·318	·9	18·01	11·51	8·25	3·603
·4	11·73	7·49	5·37	2·346	13·0	18·15	11·60	8·32	3·631
·5	11·87	7·58	5·44	2·374	·1	18·29	11·68	8·38	3·659
·6	12·01	7·67	5·50	2·402	·2	18·43	11·77	8·44	3·687
·7	12·15	7·76	5·57	2·430	·3	18·57	11·86	8·51	3·714
·8	12·29	7·85	5·63	2·458	·4	18·71	11·95	8·57	3·742
·9	12·43	7·94	5·69	2·486	·5	18·85	12·04	8·64	3·770
9·0	12·57	8·03	5·76	2·514	·6	18·99	12·13	8·70	3·798
·1	12·71	8·12	5·82	2·541	·7	19·13	12·22	8·76	3·826
·2	12·85	8·21	5·89	2·569	·8	19·27	12·31	8·83	3·854
·3	12·99	8·30	5·95	2·597	·9	19·41	12·40	8·89	3·882
·4	13·13	8·38	6·01	2·625	14·0	19·55	12·49	8·96	3·910
·5	13·27	8·47	6·08	2·653	·1	19·69	12·58	9·02	3·938
·6	13·41	8·56	6·14	2·681	·2	19·83	12·67	9·08	3·966
·7	13·55	8·65	6·21	2·709	·3	19·97	12·76	9·15	3·994
·8	13·69	8·74	6·27	2·737	·4	20·11	12·84	9·21	4·022
·9	13·83	8·83	6·33	2·765	·5	20·25	12·93	9·28	4·050
10·0	13·96	8·92	6·40	2·793	·6	20·39	13·02	9·34	4·078
·1	14·10	9·01	6·46	2·821	·7	20·53	13·11	9·40	4·105
·2	14·24	9·10	6·52	2·849	·8	20·67	13·20	9·47	4·133
·3	14·38	9·19	6·59	2·877	·9	20·81	13·29	9·53	4·161
·4	14·52	9·28	6·65	2·905	15·0	20·95	13·38	9·60	4·189
·5	14·66	9·37	6·72	2·932	·1	21·09	13·47	9·66	4·217
·6	14·80	9·45	6·78	2·960	·2	21·23	13·56	9·72	4·245
·7	14·94	9·54	6·84	2·988	·3	21·37	13·65	9·79	4·273
·8	15·08	9·63	6·91	3·016	·4	21·50	13·74	9·85	4·301
·9	15·22	9·72	6·97	3·044	·5	21·64	13·83	9·92	4·329
11·0	15·36	9·81	7·04	3·072	·6	21·78	13·91	9·98	4·357
·1	15·50	9·90	7·10	3·100	·7	21·92	14·00	10·04	4·385
·2	15·64	9·99	7·16	3·128	·8	22·06	14·09	10·11	4·413
·3	15·78	10·08	7·23	3·156	·9	22·20	14·18	10·17	4·441
·4	15·92	10·17	7·29	3·184	16·0	22·34	14·27	10·23	4·469
·5	16·06	10·26	7·36	3·212	·1	22·48	14·36	10·30	4·496
·6	16·20	10·35	7·42	3·240	·2	22·62	14·45	10·36	4·524
·7	16·34	10·44	7·48	3·268	·3	22·76	14·54	10·43	4·552
·8	16·48	10·53	7·55	3·296	·4	22·90	14·63	10·49	4·580
·9	16·62	10·61	7·61	3·324	·5	23·04	14·72	10·55	4·608
12·0	16·76	10·70	7·68	3·351	·6	23·18	14·81	10·62	4·636
·1	16·90	10·79	7·74	3·379	·7	23·32	14·89	10·68	4·664
·2	17·04	10·88	7·80	3·407	·8	23·46	14·98	10·75	4·692
·3	17·18	10·97	7·87	3·435	·9	23·60	15·07	10·81	4·720
·4	17·32	11·06	7·93	3·463	17·0	23·74	15·16	10·87	4·748
·5	17·46	11·15	8·00	3·491	·1	23·88	15·25	10·94	4·776
·6	17·60	11·24	8·06	3·519	·2	24·02	15·34	11·00	4·804

TABLE FOR PHOSPHATES—*continued.*

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
17·3	24·16	15·43	11·07	4·832	21·3	29·74	19·00	13·62	5·949
·4	24·30	15·52	11·13	4·860	·4	29·88	19·09	13·69	5·977
·5	24·44	15·61	11·19	4·887	·5	30·02	19·18	13·75	6·005
·6	24·58	15·70	11·26	4·915	·6	30·16	19·27	13·82	6·033
·7	24·72	15·79	11·32	4·943	·7	30·30	19·35	13·88	6·060
·8	24·86	15·88	11·39	4·971	·8	30·44	19·44	13·94	6·088
·9	25·00	15·97	11·45	4·999	·9	30·58	19·53	14·01	6·116
18·0	25·14	16·05	11·51	5·027	22·0	30·72	19·62	14·07	6·144
·1	25·27	16·14	11·58	5·055	·1	30·86	19·71	14·14	6·172
·2	25·41	16·23	11·64	5·083	·2	31·00	19·80	14·20	6·200
·3	25·55	16·32	11·71	5·111	·3	31·14	19·89	14·26	6·228
·4	25·69	16·41	11·77	5·139	·4	31·28	19·98	14·33	6·256
·5	25·83	16·50	11·83	5·167	·5	31·42	20·07	14·39	6·284
·6	25·97	16·59	11·90	5·195	·6	31·56	20·16	14·46	6·312
·7	26·11	16·68	11·96	5·223	·7	31·70	20·25	14·52	6·340
·8	26·25	16·77	12·03	5·250	·8	31·84	20·34	14·58	6·368
·9	26·39	16·86	12·09	5·278	·9	31·98	20·43	14·65	6·396
19·0	26·53	16·95	12·15	5·306	23·0	32·12	20·51	14·71	6·423
·1	26·67	17·04	12·22	5·334	·1	32·26	20·60	14·78	6·451
·2	26·81	17·12	12·28	5·362	·2	32·40	20·69	14·84	6·479
·3	26·95	17·21	12·35	5·390	·3	32·54	20·78	14·90	6·507
·4	27·09	17·30	12·41	5·418	·4	32·68	20·87	14·97	6·535
·5	27·23	17·39	12·47	5·446	·5	32·82	20·96	15·03	6·563
·6	27·37	17·48	12·54	5·474	·6	32·96	21·05	15·10	6·591
·7	27·51	17·57	12·60	5·502	·7	33·09	21·14	15·16	6·619
·8	27·65	17·66	12·67	5·530	·8	33·23	21·23	15·22	6·647
·9	27·79	17·75	12·73	5·558	·9	33·37	21·32	15·29	6·675
20·0	27·93	17·84	12·79	5·586	24·0	33·51	21·41	15·35	6·703
·1	28·07	17·93	12·86	5·614	·1	33·65	21·50	15·42	6·731
·2	28·21	18·02	12·92	5·642	·2	33·79	21·58	15·48	6·759
·3	28·35	18·11	12·99	5·669	·3	33·93	21·67	15·54	6·787
·4	28·49	18·20	13·05	5·697	·4	34·07	21·76	15·61	6·814
·5	28·63	18·28	13·11	5·725	·5	34·21	21·85	15·67	6·842
·6	28·77	18·37	13·18	5·753	·6	34·35	21·94	15·74	6·870
·7	28·91	18·46	13·24	5·781	·7	34·49	22·03	15·80	6·898
·8	29·05	18·55	13·31	5·809	·8	34·63	22·12	15·86	6·926
·9	29·19	18·64	13·37	5·837	·9	34·77	22·21	15·93	6·954
21·0	29·32	18·73	13·43	5·865	25·0	34·91	22·30	15·99	6·982
·1	29·46	18·82	13·50	5·893	·1	35·05	22·39	16·06	7·010
·2	29·60	18·91	13·56	5·921	·2	35·19	22·48	16·12	7·038

$Mg_2P_2O_7$	·01	·02	·03	·04	·05	·06	·07	·08	·09
$Ca_3P_2O_8$	·01	·03	·04	·06	·07	·08	·10	·11	·13
CaP_2O_6	·01	·02	·03	·04	·05	·05	·06	·07	·08
P_2O_5	·01	·01	·02	·03	·03	·04	·05	·05	·06
P_2	·003	·006	·008	·011	·014	·017	·020	·022	·025

TABLE FOR PHOSPHATES—*continued.*

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
25·3	35·33	22·57	16·18	7·066	29·9	41·75	26·67	19·13	8·351
·4	35·47	22·66	16·25	7·094	30·0	41·89	26·76	19·19	8·378
·5	35·61	22·74	16·31	7·122	·1	42·03	26·85	19·25	8·406
·6	35·75	22·83	16·38	7·150	·2	42·17	26·94	19·32	8·434
·7	35·89	22·92	16·44	7·178	·3	42·31	27·03	19·38	8·462
·8	36·03	23·01	16·50	7·205	·4	42·45	27·11	19·45	8·490
·9	36·17	23·10	16·57	7·233	·5	42·59	27·20	19·51	8·518
26·0	36·31	23·19	16·63	7·261	·6	42·73	27·29	19·57	8·546
·1	36·45	23·28	16·70	7·289	·7	42·87	27·38	19·64	8·574
·2	36·59	23·37	16·76	7·317	·8	43·01	27·47	19·70	8·602
·3	36·73	23·46	16·82	7·345	·9	43·15	27·56	19·77	8·630
·4	36·87	23·55	16·89	7·373	31·0	43·29	27·65	19·83	8·658
·5	37·00	23·64	16·95	7·401	·1	43·43	27·74	19·89	8·686
·6	37·14	23·72	17·02	7·429	·2	43·57	27·83	19·96	8·714
·7	37·28	23·81	17·08	7·457	·3	43·71	27·92	20·02	8·742
·8	37·42	23·90	17·14	7·485	·4	43·85	28·01	20·09	8·769
·9	37·56	23·99	17·21	7·513	·5	43·99	28·10	20·15	8·797
27·0	37·70	24·08	17·27	7·541	·6	44·13	28·18	20·21	8·825
·1	37·84	24·17	17·33	7·569	·7	44·27	28·27	20·28	8·853
·2	37·98	24·26	17·40	7·597	·8	44·41	28·36	20·34	8·881
·3	38·12	24·35	17·46	7·624	·9	44·55	28·45	20·41	8·909
·4	38·26	24·44	17·53	7·652	32·0	44·69	28·54	20·47	8·937
·5	38·40	24·53	17·59	7·680	·1	44·82	28·63	20·53	8·965
·6	38·54	24·62	17·65	7·708	·2	44·96	28·72	20·60	8·993
·7	38·68	24·71	17·72	7·736	·3	45·10	28·81	20·66	9·021
·8	38·82	24·80	17·78	7·764	·4	45·24	28·90	20·72	9·049
·9	38·96	24·88	17·85	7·792	·5	45·38	28·99	20·79	9·077
28·0	39·10	24·97	17·91	7·820	·6	45·52	29·08	20·85	9·105
·1	39·24	25·06	17·97	7·848	·7	45·66	29·17	20·92	9·133
·2	39·38	25·15	18·04	7·876	·8	45·80	29·26	20·98	9·160
·3	39·52	25·24	18·10	7·904	·9	45·94	29·34	21·04	9·188
·4	39·66	25·33	18·17	7·932	33·0	46·08	29·43	21·11	9·216
·5	39·80	25·42	18·23	7·959	·1	46·22	29·52	21·17	9·244
·6	39·94	25·51	18·29	7·987	·2	46·36	29·61	21·24	9·272
·7	40·08	25·60	18·36	8·015	·3	46·50	29·70	21·30	9·300
·8	40·22	25·69	18·42	8·043	·4	46·64	29·79	21·36	9·328
·9	40·36	25·78	18·49	8·071	·5	46·78	29·88	21·43	9·356
29·0	40·50	25·87	18·55	8·099	·6	46·92	29·97	21·49	9·384
·1	40·64	25·95	18·61	8·127	·7	47·06	30·06	21·56	9·412
·2	40·78	26·04	18·68	8·155	·8	47·20	30·15	21·62	9·440
·3	40·92	26·13	18·74	8·183	·9	47·34	30·24	21·68	9·468
·4	41·06	26·22	18·81	8·211	34·0	47·48	30·33	21·75	9·496
·5	41·19	26·31	18·87	8·239	·1	47·62	30·41	21·81	9·523
·6	41·33	26·40	18·93	8·267	·2	47·76	30·50	21·88	9·551
·7	41·47	26·49	19·00	8·295	·3	47·90	30·59	21·94	9·579
·8	41·61	26·58	19·06	8·323	·4	48·04	30·68	22·00	9·607

TABLE FOR PHOSPHATES—*continued.*

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
34·5	48·18	30·77	22·07	9·635	38·5	53·76	34·34	24·63	10·752
·6	48·32	30·86	22·13	9·663	·6	53·90	34·43	24·69	10·780
·7	48·46	30·95	22·20	9·691	·7	54·04	34·52	24·75	10·808
·8	48·60	31·04	22·26	9·719	·8	54·18	34·61	24·82	10·836
·9	48·74	31·13	22·32	9·747	·9	54·32	34·70	24·88	10·864
35·0	48·87	31·22	22·39	9·775	39·0	54·46	34·78	24·95	10·892
·1	49·01	31·31	22·45	9·803	·1	54·60	34·87	25·01	10·920
·2	49·15	31·40	22·52	9·831	·2	54·74	34·96	25·07	10·948
·3	49·29	31·49	22·58	9·859	·3	54·88	35·05	25·14	10·976
·4	49·43	31·57	22·64	9·887	·4	55·02	35·14	25·20	11·004
·5	49·57	31·66	22·71	9·914	·5	55·16	35·23	25·27	11·032
·6	49·71	31·75	22·77	9·942	·6	55·30	35·32	25·33	11·060
·7	49·85	31·84	22·84	9·970	·7	55·44	35·41	25·39	11·087
·8	49·99	31·93	22·90	9·998	·8	55·58	35·50	25·46	11·115
·9	50·13	32·02	22·96	10·026	·9	55·72	35·59	25·52	11·143
36·0	50·27	32·11	23·03	10·054	40·0	55·86	35·68	25·59	11·171
·1	50·41	32·20	23·09	10·082	·1	56·00	35·77	25·65	11·199
·2	50·55	32·29	23·16	10·110	·2	56·14	35·85	25·71	11·227
·3	50·69	32·38	23·22	10·138	·3	56·28	35·94	25·78	11·255
·4	50·83	32·47	23·28	10·166	·4	56·42	36·03	25·84	11·283
·5	50·97	32·55	23·35	10·194	·5	56·55	36·12	25·91	11·311
·6	51·11	32·64	23·41	10·222	·6	56·69	36·21	25·97	11·339
·7	51·25	32·73	23·48	10·250	·7	56·83	36·30	26·03	11·367
·8	51·39	32·82	23·54	10·278	·8	56·97	36·39	26·10	11·395
·9	51·53	32·91	23·60	10·306	·9	57·11	36·48	26·16	11·423
37·0	51·67	33·00	23·67	10·333	41·0	57·25	36·57	26·23	11·451
·1	51·81	33·09	23·73	10·361	·1	57·39	36·66	26·29	11·478
·2	51·95	33·18	23·80	10·389	·2	57·53	36·75	26·35	11·506
·3	52·09	33·27	23·86	10·417	·3	57·67	36·84	26·42	11·534
·4	52·23	33·36	23·92	10·445	·4	57·81	36·93	26·48	11·562
·5	52·37	33·45	23·99	10·473	·5	57·95	37·01	26·55	11·590
·6	52·51	33·54	24·05	10·501	·6	58·09	37·10	26·61	11·618
·7	52·64	33·62	24·12	10·529	·7	58·23	37·19	26·67	11·646
·8	52·78	33·71	24·18	10·557	·8	58·37	37·28	26·74	11·674
·9	52·92	33·80	24·24	10·585	·9	58·51	37·37	26·80	11·702
38·0	53·06	33·89	24·31	10·613	42·0	58·65	37·46	26·87	11·730
·1	53·20	33·98	24·37	10·641	·1	58·79	37·55	26·93	11·758
·2	53·34	34·07	24·43	10·669	·2	58·93	37·64	26·99	11·786
·3	53·48	34·16	24·50	10·696	·3	59·07	37·73	27·06	11·814
·4	53·62	34·25	24·56	10·724	·4	59·21	37·82	27·12	11·842

$Mg_2P_2O_7$	·01	·02	·03	·04	·05	·06	·07	·08	·09
$Ca_3P_2O_8$	·01	·03	·04	·06	·07	·08	·10	·11	·13
CaP_2O_6	·01	·02	·03	·04	·05	·05	·06	·07	·08
P_2O_5	·01	·01	·02	·03	·03	·04	·05	·05	·06
P_2	·003	·006	·008	·011	·014	·017	·020	·022	·025

TABLE FOR PHOSPHATES—*continued.*

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
42·5	59·35	37·91	27·19	11·869	47·1	65·77	42·01	30·13	13·154
·6	59·49	38·00	27·25	11·897	·2	65·91	42·10	30·19	13·182
·7	59·63	38·08	27·31	11·925	·3	66·05	42·19	30·26	13·210
·8	59·77	38·17	27·38	11·953	·4	66·19	42·28	30·32	13·238
·9	59·91	38·26	27·44	11·981	·5	66·33	42·37	30·38	13·266
43·0	60·05	38·35	27·51	12·009	·6	66·47	42·45	30·45	13·294
·1	60·18	38·44	27·57	12·037	·7	66·61	42·54	30·51	13·322
·2	60·32	38·53	27·63	12·065	·8	66·75	42·63	30·58	13·350
·3	60·46	38·62	27·70	12·093	·9	66·89	42·72	30·64	13·378
·4	60·60	38·71	27·76	12·121	48·0	67·03	42·81	30·70	13·405
·5	60·74	38·80	27·83	12·149	·1	67·17	42·90	30·77	13·433
·6	60·88	38·89	27·89	12·177	·2	67·31	42·99	30·83	13·461
·7	61·02	38·98	27·95	12·205	·3	67·45	43·08	30·90	13·489
·8	61·16	39·07	28·02	12·232	·4	67·59	43·17	30·96	13·517
·9	61·30	39·16	28·08	12·260	·5	67·73	43·26	31·02	13·545
44·0	61·44	39·24	28·14	12·288	·6	67·87	43·35	31·09	13·573
·1	61·58	39·33	28·21	12·316	·7	68·00	43·44	31·15	13·601
·2	61·72	39·42	28·27	12·344	·8	68·14	43·53	31·22	13·629
·3	61·86	39·51	28·34	12·372	·9	68·28	43·61	31·28	13·657
·4	62·00	39·60	28·40	12·400	49·0	68·42	43·70	31·34	13·685
·5	62·14	39·69	28·46	12·428	·1	68·56	43·79	31·41	13·713
·6	62·28	39·78	28·53	12·456	·2	68·70	43·88	31·47	13·741
·7	62·42	39·87	28·59	12·484	·3	68·84	43·97	31·53	13·769
·8	62·56	39·96	28·66	12·512	·4	68·98	44·06	31·60	13·796
·9	62·70	40·05	28·72	12·540	·5	69·12	44·15	31·66	13·824
45·0	62·84	40·14	28·78	12·568	·6	69·26	44·24	31·73	13·852
·1	62·98	40·23	28·85	12·596	·7	69·40	44·33	31·79	13·880
·2	63·12	40·31	28·91	12·624	·8	69·54	44·42	31·85	13·908
·3	63·26	40·40	28·98	12·651	·9	69·68	44·51	31·92	13·936
·4	63·40	40·49	29·04	12·679	50·0	69·82	44·60	31·98	13·964
·5	63·54	40·58	29·10	12·707	·1	69·96	44·68	32·05	13·992
·6	63·68	40·67	29·17	12·735	·2	70·10	44·77	32·11	14·020
·7	63·82	40·76	29·23	12·763	·3	70·24	44·86	32·17	14·048
·8	63·96	40·85	29·30	12·791	·4	70·38	44·95	32·24	14·076
·9	64·10	40·94	29·36	12·819	·5	70·52	45·04	32·30	14·104
46·0	64·23	41·03	29·42	12·847	·6	70·66	45·13	32·37	14·132
·1	64·37	41·12	29·49	12·875	·7	70·80	45·22	32·43	14·160
·2	64·51	41·21	29·55	12·903	·8	70·94	45·31	32·49	14·187
·3	64·65	41·30	29·62	12·931	·9	71·08	45·40	32·56	14·215
·4	64·79	41·38	29·68	12·959	51·0	71·22	45·49	32·62	14·243
·5	64·93	41·47	29·74	12·987	·1	71·36	45·58	32·69	14·271
·6	65·07	41·56	29·81	13·015	·2	71·50	45·67	32·75	14·299
·7	65·21	41·65	29·87	13·042	·3	71·64	45·76	32·81	14·327
·8	65·35	41·74	29·94	13·070	·4	71·78	45·84	32·88	14·355
·9	65·49	41·83	30·00	13·098	·5	71·91	45·93	32·94	14·383
47·0	65·63	41·92	30·06	13·126	·6	72·05	46·02	33·01	14·411

TABLE FOR PHOSPHATES—*continued.*

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
51·7	72·19	46·11	33·07	14·439	55·7	77·78	49·68	35·63	15·556
·8	72·33	46·20	33·13	14·467	·8	77·92	49·77	35·69	15·584
·9	72·47	46·29	33·20	14·495	·9	78·06	49·86	35·76	15·612
52·0	72·61	46·38	33·26	14·523	56·0	78·20	49·95	35·82	15·640
·1	72·75	46·47	33·33	14·551	·1	78·34	50·04	35·88	15·668
·2	72·89	46·56	33·39	14·579	·2	78·48	50·12	35·95	15·696
·3	73·03	46·65	33·45	14·606	·3	78·62	50·21	36·01	15·724
·4	73·17	46·74	33·52	14·634	·4	78·76	50·30	36·08	15·751
·5	73·31	46·83	33·58	14·662	·5	78·90	50·39	36·14	15·779
·6	73·45	46·91	33·65	14·690	·6	79·04	50·48	36·20	15·807
·7	73·59	47·00	33·71	14·718	·7	79·18	50·57	36·27	15·835
·8	73·73	47·09	33·77	14·746	·8	79·32	50·66	36·33	15·863
·9	73·87	47·18	33·84	14·774	·9	79·46	50·75	36·40	15·891
53·0	74·01	47·27	33·90	14·802	57·0	79·60	50·84	36·46	15·919
·1	74·15	47·36	33·97	14·830	·1	79·74	50·93	36·52	15·947
·2	74·29	47·45	34·03	14·858	·2	79·87	51·02	36·59	15·975
·3	74·43	47·54	34·09	14·886	·3	80·01	51·11	36·65	16·003
·4	74·57	47·63	34·16	14·914	·4	80·15	51·20	36·72	16·031
·5	74·71	47·72	34·22	14·941	·5	80·29	51·28	36·78	16·059
·6	74·85	47·81	34·29	14·969	·6	80·43	51·37	36·84	16·087
·7	74·99	47·90	34·35	14·997	·7	80·57	51·46	36·91	16·115
·8	75·13	47·99	34·41	15·025	·8	80·71	51·55	36·97	16·142
·9	75·27	48·07	34·48	15·053	·9	80·85	51·64	37·04	16·170
54·0	75·41	48·16	34·54	15·081	58·0	80·99	51·73	37·10	16·198
·1	75·55	48·25	34·61	15·109	·1	81·13	51·82	37·16	16·226
·2	75·69	48·34	34·67	15·137	·2	81·27	51·91	37·23	16·254
·3	75·83	48·43	34·73	15·165	·3	81·41	52·00	37·29	16·282
·4	75·97	48·52	34·80	15·193	·4	81·55	52·09	37·36	16·310
·5	76·10	48·61	34·86	15·221	·5	81·69	52·18	37·42	16·338
·6	76·24	48·70	34·93	15·249	·6	81·83	52·27	37·48	16·366
·7	76·38	48·79	34·99	15·277	·7	81·97	52·35	37·55	16·394
·8	76·52	48·88	35·05	15·305	·8	82·11	52·44	37·61	16·422
·9	76·66	48·97	35·12	15·333	·9	82·25	52·53	37·68	16·450
55·0	76·80	49·06	35·18	15·360	59·0	82·39	52·62	37·74	16·478
·1	76·94	49·14	35·24	15·388	·1	82·53	52·71	37·80	16·505
·2	77·08	49·23	35·31	15·416	·2	82·67	52·80	37·87	16·533
·3	77·22	49·32	35·37	15·444	·3	82·81	52·89	37·93	16·561
·4	77·36	49·41	35·44	15·472	·4	82·95	52·98	38·00	16·589
·5	77·50	49·50	35·50	15·500	·5	83·09	53·07	38·06	16·617
·6	77·64	49·59	35·56	15·528	·6	83·23	53·16	38·12	16·645

$Mg_2P_2O_7$	·01	·02	·03	·04	·05	·06	·07	·08	·09
$Ca_3P_2O_8$	·01	·03	·04	·06	·07	·08	·10	·11	·13
CaP_2O_6	·01	·02	·03	·04	·05	·05	·06	·07	·08
P_2O_5	·01	·01	·02	·03	·03	·04	·05	·05	·06
P_2	·003	·006	·008	·011	·014	·017	·020	·022	·025

TABLE FOR PHOSPHATES—*continued.*

$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2	$Mg_2P_2O_7$	$Ca_3P_2O_8$	CaP_2O_6	P_2O_5	P_2
59·7	83·37	53·25	38·19	16·673	61·0	85·18	54·41	39·02	17·036
·8	83·51	53·34	38·25	16·701	62	86·58	55·30	39·66	17·315
·9	83·65	53·43	38·32	16·729	63	87·97	56·19	40·30	17·595
60·0	83·78	53·51	38·38	16·757	64	89·37	57·08	40·94	17·874
·1	83·92	53·60	38·44	16·785	65	90·77	57·97	41·58	18·153
·2	84·06	53·69	38·51	16·813	66	92·16	58·87	42·22	18·433
·3	84·20	53·78	38·57	16·841	67	93·56	59·76	42·86	18·712
·4	84·34	53·87	38·63	16·869	68	94·96	60·65	43·50	18·991
·5	84·48	53·96	38·70	16·896	69	96·35	61·54	44·14	19·270
·6	84·62	54·05	38·76	16·924	70	97·75	62·43	44·78	19·550
·7	84·76	54·14	38·83	16·952	71	99·14	63·33	45·41	19·829
·8	84·90	54·23	38·89	16·980		100·00	63·87	45·81	20·000
·9	85·04	54·32	38·95	17·008					

TABLE FOR THE CONVERSION OF NITROGEN INTO AMMONIA AND ALBUMINOIDS ($=N \times 6·25$).

N.	NH_3.	Albuminoids ($N \times 6·25$).	N.	NH_3.	Albuminoids ($N \times 6·25$).	N.	NH_3.	Albuminoids ($N \times 6·25$).
0·1	0·12	0·63	1·9	2·31	11·88	3·7	4·49	23·13
·2	·24	1·25	2·0	2·43	12·50	·8	4·61	23·75
·3	·36	1·88	·1	2·55	13·13	·9	4·73	24·38
·4	·49	2·50	·2	2·67	13·75	4·0	4·86	25·00
·5	·61	3·13	·3	2·79	14·38	·1	4·98	25·63
·6	·73	3·75	·4	2·91	15·00	·2	5·10	26·25
·7	·85	4·38	·5	3·04	15·63	·3	5·22	26·88
·8	·97	5·00	·6	3·16	16·25	·4	5·34	27·50
·9	1·09	5·63	·7	3·28	16·88	·5	5·46	28·13
1·0	1·21	6·25	·8	3·40	17·50	·6	5·58	28·75
·1	1·34	6·88	·9	3·52	18·13	·7	5·71	29·38
·2	1·46	7·50	3·0	3·64	18·75	·8	5·83	30·00
·3	1·58	8·13	·1	3·76	19·38	·9	5·95	30·63
·4	1·70	8·75	·2	3·88	20·00	5·0	6·08	31·25
·5	1·82	9·38	·3	4·01	20·63	·1	6·20	31·88
·6	1·94	10·00	·4	4·13	21·25	·2	6·32	32·50
·7	2·06	10·63	·5	4·25	21·88	·3	6·44	33·13
·8	2·19	11·25	·6	4·37	22·50	·4	6·57	33·75

N	·01	·02	·03	·04	·05	·06	·07	·08	·09
NH_3	·01	·02	·04	·05	·06	·07	·09	·10	·11
Albuminoids	·06	·13	·19	·25	·31	·38	·44	·50	·56

TABLE FOR THE CONVERSION OF NITROGEN INTO AMMONIA AND ALBUMINOIDS—*continued.*

N.	NH_3.	Albuminoids ($N \times 6·25$).	N.	NH_3.	Albuminoids ($N \times 6·25$).	N.	NH_3.	Albuminoids ($N \times 6·25$).
5·5	6·69	34·38	9·1	11·06	56·88	12·6	15·32	78·75
·6	6·81	35·00	·2	11·19	57·50	·7	15·44	79·38
·7	6·93	35·63	·3	11·31	58·13	·8	15·56	80·00
·8	7·05	36·25	·4	11·43	58·75	·9	15·68	80·63
·9	7·17	36·88	·5	11·55	59·38	13·0	15·81	81·25
6·0	7·30	37·50	·6	11·67	60·00	·1	15·93	81·88
·1	7·42	38·13	·7	11·79	60·63	·2	16·05	82·50
·2	7·54	38·75	·8	11·92	61·25	·3	16·17	83·13
·3	7·66	39·38	·9	12·04	61·88	·4	16·29	83·75
·4	7·78	40·00	10·0	12·16	62·50	·5	16·41	84·38
·5	7·90	40·63	·1	12·28	63·13	·6	16·54	85·00
·6	8·02	41·25	·2	12·40	63·75	·7	16·66	85·63
·7	8·15	41·88	·3	12·52	64·38	·8	16·78	86·25
·8	8·27	42·50	·4	12·64	65·00	·9	16·90	86·88
·9	8·39	43·13	·5	12·77	65·63	14·0	17·02	87·50
7·0	8·51	43·75	·6	12·89	66·25	·1	17·14	88·13
·1	8·63	44·38	·7	13·01	66·88	·2	17·27	88·75
·2	8·75	45·00	·8	13·13	67·50	·3	17·39	89·38
·3	8·88	45·63	·9	13·25	68·13	·4	17·51	90·00
·4	9·00	46·25	11·0	13·37	68·75	·5	17·63	90·63
·5	9·12	46·88	·1	13·50	69·38	·6	17·75	91·25
·6	9·24	47·50	·2	13·62	70·00	·7	17·87	91·88
·7	9·36	48·13	·3	13·74	70·63	·8	17·99	92·50
·8	9·48	48·75	·4	13·86	71·25	·9	18·12	93·13
·9	9·61	49·38	·5	13·98	71·88	15·0	18·24	93·75
8·0	9·73	50·00	·6	14·10	72·50	·1	18·36	94·38
·1	9·85	50·63	·7	14·23	73·13	·2	18·48	95·00
·2	9·97	51·25	·8	14·35	73·75	·3	18·60	95·63
·3	10·09	51·88	·9	14·47	74·38	·4	18·72	96·25
·4	10·21	52·50	12·0	14·59	75·00	·5	18·85	96·88
·5	10·33	53·13	·1	14·71	75·63	·6	18·97	97·50
·6	10·46	53·75	·2	14·83	76·25	·7	19·09	98·13
·7	10·58	54·38	·3	14·95	76·88	·8	19·21	98·75
·8	10·70	55·00	·4	15·08	77·50	·9	19·33	99·38
·9	10·82	55·63	·5	15·20	78·13	16·0	19·45	100·00
9·0	10·94	56·25						

N	·01	·02	·03	·04	·05	·06	·07	·08	·09
NH_3	·01	·02	·04	·05	·06	·07	·09	·10	·11
Albuminoids	·06	·13	·19	·25	·31	·38	·44	·50	·56

TABLE FOR KJELDAHL PROCESS: 1 GRAM OF SUBSTANCE BEING USED.

1 c.c. N/5 acid = 0·002802 gram N (log. $\bar{3}$·44747)
" = 0·003407 gram NH_3 (log. $\bar{3}$·53237).

c.c. N/5 acid used.	% N.	% NH_3.	c.c. N/5 acid used.	% N.	% NH_3.	c.c. N/5 acid used.	% N.	% NH_3.
1	0·28	0·34	25	7·01	8·52	49	13·73	16·69
2	0·56	0·68	26	7·29	8·86	50	14·01	17·04
3	0·84	1·02	27	7·57	9·20	51	14·29	17·38
4	1·12	1·36	28	7·85	9·54	52	14·57	17·72
5	1·40	1·70	29	8·13	9·88	53	14·85	18·06
6	1·68	2·04	30	8·41	10·22	54	15·13	18·40
7	1·96	2·38	31	8·69	10·56	55	15·41	18·74
8	2·24	2·73	32	8·97	10·90	56	15·69	19·08
9	2·52	3·07	33	9·25	11·24	57	15·97	19·42
10	2·80	3·41	34	9·53	11·58	58	16·25	19·76
11	3·08	3·75	35	9·81	11·92	59	16·53	20·10
12	3·36	4·09	36	10·09	12·27	60	16·81	20·44
13	3·64	4·43	37	10·37	12·61	61	17·09	20·78
14	3·92	4·77	38	10·65	12·95	62	17·37	21·12
15	4·20	5·11	39	10·93	13·29	63	17·65	21·46
16	4·48	5·45	40	11·21	13·63	64	17·93	21·80
17	4·76	5·79	41	11·49	13·97	65	18·21	22·15
18	5·04	6·13	42	11·77	14·31	66	18·49	22·49
19	5·32	6·47	43	12·05	14·65	67	18·77	22·83
20	5·60	6·81	44	12·33	14·99	68	19·05	23·17
21	5·88	7·15	45	12·61	15·33	69	19·33	23·51
22	6·16	7·50	46	12·89	15·67	70	19·61	23·85
23	6·44	7·84	47	13·17	16·01	71	19·89	24·19
24	6·72	8·18	48	13·45	16·35	72	20·17	24·53

c.c. N/5 acid	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9
% N	·03	·06	·08	·11	·14	·17	·20	·22	·25
% NH_3	·03	·07	·10	·14	·17	·20	·24	·27	·31

FACTORS FOR CALCULATING VARIOUS NITROGENOUS SUBSTANCES.

	Multiply Nitrogen by	Logarithm.	Authority.
Albuminoids . . .	6·25	0·79588	...
Albumin . . .	6·39	0·80550	Richmond
Casein	6·39	,,	,,
Proteins of cheese . .	6·39	,,	,,
,, milk . .	6·39	,,	,,
,, dried milk .	6·87	0·83696	,,
Gelatin	5·5	0·74036	Allen and Searle: Mitchell
Proteins in meat-extract	6·33	0·80140	Allen and Searle
Hide substance (from nitrogen in leather) .	5·62	0·74958	J. G. Parker

The comparative values of feeding stuffs * are frequently expressed in terms of "food units," which are calculated as follows:—

Multiply the sum of the percentages of oil and albuminoids by $2\frac{1}{2}$ and add the percentage of "digestible carbohydrates." The result gives the percentage of food units.

Ex. Two linseed cakes contained

	A	B
Oil	14·36	10·06
Albuminoids	27·42	28·50
Digestible carbohydrates . .	32·59	34·13

Hence we have

A 14·36
27·42

$41{\cdot}78 \times 2\frac{1}{2}\dagger = 104{\cdot}45 + 32{\cdot}59 =$ Food Units. 137

B 10·06
28·50

$38{\cdot}56 \times 2\frac{1}{2} = 96{\cdot}40 + 34{\cdot}13 = 130{\cdot}5.$

The relative values of A and B are thus

137 : 130·5, or 1·05 : 1.

It must be specially noticed that "food units" express the *total intrinsic value* of a feeding stuff—both as food, and as manure after it has passed through the animal.

* Dyer, *Fertilizers and Feeding Stuffs*, p. 81.

† Best done by using the equivalent fraction $\frac{10}{4}$, thus $\frac{417{\cdot}8}{4} = 104{\cdot}45$.

Oils, Fats, and Waxes.

Oils are neutral bodies of more or less viscous consistence, liquid at the ordinary temperature, combustible, lighter than water and insoluble in it, sometimes soluble in alcohol, and always soluble in ether. Oils are classified as follows:—(i) *fatty* or *fixed* oils; (ii) *essential* or *volatile* oils; and (iii) *mineral* oils. The *fatty* or *fixed* oils are simply liquid fats, and, in contradistinction to the members of the second class, decompose when heated. *Essential* oils have strong and characteristic odours, and are vapourizable without decomposition, usually with little or no residue. Many essential oils consist of hydrocarbons or other fluid bodies mixed with solid oxidized compounds. On cooling such, or by evaporation, the latter often crystallize out, the solid thus separating being termed the *stearoptene*, whilst the liquid is called the *elaeoptene*. *Mineral* oils form a class somewhat by themselves, and include petroleum and oils distilled from peat, shale, etc.: they consist of mixtures of hydrocarbons.

Fats are the (neutral) triglycerides of the higher fatty acids. A great many fats may be considered as mixtures of the triglycerides of several fatty acids, as of tripalmitin, tristearin and triolein; but mixed esters of glycerol may also exist in fats, *e.g.*, oleo-palmito-butyrate in butter-fat.

Waxes are esters formed by the union of mono- or di-hydric alcohols with the higher fatty acids. The waxes, therefore, do not contain glycerol, and consequently, on being heated, do not emit the odour of acrolein, neither do they, on keeping, become rancid, owing to the stability of the esters of which they consist. Waxes are derived from both the animal and the vegetable kingdoms, beeswax being typical of the former, and carnaüba wax of the latter.

Japan wax consists chiefly of glycerides, and hence is classed among "fats": whilst sperm oil contains only a small amount of glycerides, but a large percentage of unsaponifiable matter, and is classed among "waxes."

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(1) The *acid value* is the measure of the amount of free fatty acids in a fat or wax. It gives the number of milligrams of potassium hydroxide required to neutralize the free fatty acids in one gram of a fat or wax.

(2) The *saponification value*, or *Köttstorfer value*, is the number of milligrams of potassium hydroxide required to saponify completely one gram of a fat or wax (or gives grams of KHO required for 1000 grams of a fat or wax).

(3) The *ester value* gives the number of milligrams of potassium hydroxide required for the saponification of the neutral esters in one gram of a fat or wax.

If a fat contains no free fatty acids, (3) is identical with (2); but in the more usual case, in which small quantities of free fatty acids are present, (3) is obtained by subtracting (1) from (2).

(4) The *iodine value* gives the percentage of iodine absorbed by a fat or wax.

(5) The *Hehner value* gives the percentage of insoluble fatty acids in a fat or wax. For most fats it lies between 95 and 97.

(6) The *Reichert-Meissl value* gives the number of c.c. of decinormal alkali (barium or potassium hydroxide) required to neutralize the distillate of volatile acids obtained from 5 grams of a fat or wax by the Reichert distillation process.

Tables of Constants of Oils, Fats, and Waxes.

I.—Vegetable Oils.

Name of Oil.	Sp. gr. at 15·5/15·5° C.	Solidifying Point (° C.).	Hehner Value.*	Saponification Value.	Iodine Value.	Oleo-refractometer (Jean) @ 22° C.	Butyro-refractometer (Zeiss).
Almond (N–D) . . .	0·914 –·920	−10 to −20	96	190–195	93–100	+8 to +10·5	62–62·5 @ 30° C.
Apricot kernel (N–D) . .	0·917 –·920	−20	..	188–193	100–109	..	57–58 @ 40° C.
Arachis † (Earth-nut) [N–D]	0·911 –·926	0 to + 2	95–96	186–196	83–101	+4 to +7	64 @ 30° C.
Castor (S–D) . . .	0·960 –·967	−10 to −12	..	177–183	84–90	+39 to +42	74–76·5 @ 30° C.
Cotton-seed (S–D) . .	0·922 –·930	3 – 4	95–96	191–196	105–116	+15 to +23	64–66 @ 30° C.
Croton (S–D) . . .	0·9375–·9428	− 7	89	193–215	102–109	+35	68 @ 40° C.
Hemp seed (D) . . .	0·925 –·931	−15 to −18	..	190–193	145–166	+34 to +37·5	..
Linseed (D)	0·9315–·9410	−16 to −20	95–95·5	190–195	170–201	+48 to +54	80–81 @ 30° C.
Maize (S–D)	0·9213–·9274	−10 to −15	93	188–193	116–130	+25 .	68·5 @ 30° C.
Black mustard (S–D) . .	0·9155–·9185	−17	96	173–175	104–120	..	59·5 @ 40° C.
White mustard (S–D) . .	0·914 –·916	−16	96–96·5	170–174	92–103	..	58·5 @ 40° C.
Niger seed (D) . . .	0·9248–·927	− 9	95·5	189–192	126–134	+26 to +30	63 @ 40° C.
Olive (N–D)	0·914 –·920	Turbid at +2	..	185–196	78–94	0 to +3·5	58–60 @ 30° C.
Peach kernel (N–D) . .	0·918 –·921	below −20	..	191–198	92–99	+7·5 to +11·5	63–63·5 @ 30° C.
Poppy seed (D) . . .	0·924 –·927	−15 to −20	95·5	193–198	132–158	+30 to +35	63·4 @ 40° C.
Pumpkin seed (S–D) . .	0·920 –·925	−15	96	188–190	121–130	..	70–72 @ 25° C.
Rape (Colza) [S–D] . .	0·914 –·918	−10	94·5–96·5	168–179	96–105	+16 to +20	66·5 @ 30° C.
Sesamé (S–D) . . .	0·921 –·924	− 4 to − 6	95–96	188–193	103–115	+13 to +17	60 @ 40° C.
Sunflower (D) . . .	0·924 –·926	below −17	..	188–193	120–133	+35	72·2 @ 25° C.
Walnut (Nut) [D] . .	0·925 –·9265	−12 to −24	94–94·5	190–197	143–160	+35 to +36	65–68 @ 40° C.
Wheat (S–D) . . .	0·924 –·937	semi-solid at 0°	..	183–190	115	..	74·5 @ 35° C.

D=drying. S–D=semi-drying. N–D=non-drying.

* The values recorded in this column include the unsaponifiable matter present. Hence here, as usually, Hehner value=insoluble fatty acids+unsaponifiable matter.

† Or Peanut oil.

Note.—In Zeiss's Butyro-refractometer a rise of temperature of 1° C. causes a lowering of 0·55 scale-division *approximately*.

TABLES OF CONSTANTS OF OILS, FATS, AND WAXES.

II.—ANIMAL OILS.

Name of Oil.	Sp. gr. @ 15·5/15·5° C.	Solidifying Point (°C.).	Hehner Value.	Saponification Value.	Iodine Value.	Oleo-refractometer (Jean) @ 22° C.	Butyro-refractometer (Zeiss).
Cod liver	0·922–·930	0 to − 10	95·5	179–190	154–170	+ 40 to + 48	74–76 @ 30° C.
Lard oil	0·918–·919	− 4 to + 10	97	193–198	67–82	0·0 to − 1	58·5 @ 30° C.
Neat's foot	*0·914–·917	− 8 to − 4	94·5–95·9	194–199	66–73	− 1 to − 4	58 @ 30° C.
Seal	0·924–·929	− 2 to − 3	93–96	189–196	130–152	+ 30 to + 38	64–65 @ 40° C.
Shark liver	0·916–·919	..	87–97	157–164	115–139	+ 29 to + 35	..
Sheep's foot	0·9175	0 to 1·5	..	194·75	74–74·4	0	..

III.—ANIMAL FATS.

Name of Fat.	Sp. gr. @ 99°/15·5° C.	Solidifying Point (°C.).	Hehner Value.	Saponification Value.	Iodine Value.	Oleo-refractometer (Jean).	Butyro-refractometer (Zeiss).
Lard	†0·859–·861	27 − 30	93–95	195–203	58–68	− 5 to − 13 @ 45° C.	56·5–57 @ 30° C.
Beef Tallow . . .	0·860–·861	38 − 46	95–96	194–200	40–47	− 15 to − 18 @ 45° C.	49 @ 40° C.
Mutton Tallow . . .	0·858–·860	40 − 48	95–96	192–195	35–48	..	..

* 906·6 @ 100° F/100° F.

† 0·905–·907 @ 100° F/100° F.

Tables of Constants of Oils, Fats, and Waxes.

IV.—Vegetable Fats.

Name of Fat.	Sp. gr. @ 15·5/15·5° C.	Melting Point (°C.).	Hehner Value.	Saponification Value.	Iodine Value.	Butyro-refractometer (Zeiss).
Cacao butter	0·964 –·976	30–34	..	192–195	32–42	46–48 @ 40° C.
Cocoa-nut oil	0·910 –·9167*	23–27	82·4–90	252–268	8·2–9·5	33–40·5 @ 30° C.
Japan wax	0·984 –·993	50·4–56	90–90·5	214–222	4·2–11	..
Nutmeg butter (mace butter) .	0·945 –·996	43–51	..	154–161	43–85	61–67 @ 40° C.
Palm oil	0·921 –·924	27–43	94·5–97	200–205	53–58	..
Shea butter (Galam butter) . .	0·9175–·918	23–28	94·8	178–192	54–59	..

V.—Waxes.

Name of Wax.	Sp. gr. @ 15·5/15·5° C.	Melting Point (°C.).	Acid Value.	Saponification Value.	Iodine Value.	Butyro-refractometer (Zeiss).
Beeswax	0·958– ·963	63–66	18–21	90–100	7–13	43·0–45·6 @ 40° C.
Carnaüba wax	0·995–1·000	83–86	4–8	79–84	13·5	65·7–69 @ 40° C.
Chinese wax (Insect wax) . .	0·970	81–83	1·5	80–93	1·4	..
Spermaceti	0·942–·960	42–49	0·0–1·8	122–130	3–4	..
Sperm oil†	0·875–·884	..	..	124–144	81–87	46·2 @ 40° C.
Wool-fat (Lanolin)	0·973	36–41	0·6–2·8	98–102	17–27	..

* At 100° F./100° F. † Unsaponifiable matter, 33–40%. Fatty acids 57–64%.

TABLE SHOWING REICHERT-MEISSL VALUES FOR CERTAIN OILS, FATS, AND WAXES.

(c.c. N/10 alkali required by 5 grams.)

Almond oil	0·5	Linseed oil	0·0
Apricot kernel oil	0·0	Maize oil	4–4·5
Arachis oil	0·0–1·6	Neat's foot oil	0·9–1·2
Beeswax	0·34–0·54	Niger seed oil	0·11–0·63
Cacao butter	0·2–0·8	Nutmeg butter	1–4·2
Castor oil	1·1	Olive oil	0 6
Cocoa-nut oil	7·0–7·8	Palm oil	0·8–1·9
Cod-liver oil	0·4–0·8	Rape oil	0·0–0·8
Cotton-seed oil	0·7–0·9	Sesamé oil	1–2
Croton oil	12–13·5	Sperm oil	0·6
Lard	0·5–0·77	Wheat oil	2–3

ESSENTIAL OILS.

The following results were obtained in the laboratory of Schimmel & Co., and are considered to have been established with certainty.*

	Sp. gr. 15° C. /15°.	Rotation observed directly in 100 mm. tube with sodium light @ 20° C.
Oil of bergamot	0·883–·886	+ 9° to +15° not above 20°
,, lemon	0·858–·861	+59° to +67° not below 59°
,, orange (sweet)	0·848–·852	+96° to +98° not below 96°
,, ,, (bitter)	,,	+92° to +98° not below 92° (limonene)

OILS AND FATS.

TABLE OF SAPONIFICATION VALUES.

5 Grams Saponified.

1 c.c. N/2 acid = 0·02805 gram KOH (log. $\bar{2}$·44793).

No. of c.c. N/2 acid used.	Saponification value.	No. of c.c. N/2 acid used.	Saponification value.
	+0·1 c.c. = +0·56		+0·1 c.c. = +0·56
30·0	168·30	31·0	173·91
·2	169·42	·2	175·03
·4	170·54	·4	176·15
·6	171·67	·6	177·28
·8	172·79	·8	178·40

* From Landolt's *Optical Rotating Power of Organic Substances.*

OILS AND FATS.

TABLE OF SAPONIFICATION VALUES—*continued.*

5 Grams Saponified.

1 c.c. N/2 acid = 0·02805 gram KOH (log. $\bar{2}$·44793).

No. of c.c. N/2 acid used.	Saponification value.	No. of c.c. N/2 acid used.	Saponification value.
	+0·1 c.c. = +0·56		+0·1 c.c. = +0·56
32·0	179·52	37·8	212·06
·2	180·64	38·0	213·18
·4	181·76	·2	214·30
·6	182·89	·4	215·42
·8	184·01	·6	216·55
33·0	185·13	·8	217·67
·2	186·25	39·0	218·79
·4	187·37	·2	219·91
·6	188·50	·4	221·03
·8	189·62	·6	222·16
34·0	190·74	·8	223·28
·2	191·86	40·0	224·40
·4	192·98	·2	225·52
·6	194·11	·4	226·64
·8	195·23	·6	227·77
35·0	196·35	·8	228·89
·2	197·47	41·0	230·01
·4	198·59		
·6	199·72	1·0	5·61
·8	200·84	2·0	11·22
36·0	201·96	3·0	16·83
·2	203·08	4·0	22·44
·4	204·20	5·0	28·05
·6	205·33	6·0	33·66
·8	206·45	7·0	39·27
37·0	207·57	8·0	44·88
·2	208·69	9·0	50·49
·4	209·81	10·0	56·10
·6	210·94		

The *Saponification Equivalent* of a fat is the number of grams that would be saponified by 1 litre of a normal solution of *any* alkali. It is the quotient obtained by dividing 56108 by the saponification value.

Soluble or Volatile Acids in Butter Fat.

5 Grams Butter Fat being taken.

c.c. $\frac{N}{10}$ Alkali.	% Soluble or Volatile Acids.*	c.c. $\frac{N}{10}$ Alkali.	% Soluble or Volatile Acids.	c.c. $\frac{N}{10}$ Alkali.	% Soluble or Volatile Acids.
1·0	0·18	13·5	2·38	26·0	4·58
1·5	0·26	14·0	2·46	26·5	4·66
2·0	0·35	14·5	2·55	27·0	4·75
2·5	0·44	15·0	2·64	27·5	4·84
3·0	0·53	15·5	2·73	28·0	4·93
3·5	0·62	16·0	2·82	28·5	5·02
4·0	0·70	16·5	2·90	29·0	5·10
4·5	0·79	17·0	2·99	29·5	5·19
5·0	0·88	17·5	3·08	30·0	5·28
5·5	0·97	18·0	3·17	30·5	5·37
6·0	1·06	18·5	3·26	31·0	5·46
6·5	1·14	19·0	3·34	31·5	5·54
7·0	1·23	19·5	3·43	32·0	5·63
7·5	1·32	20·0	3·52	32·5	5·72
8·0	1·41	20·5	3·61	33·0	5·81
8·5	1·50	21·0	3·70	33·5	5·90
9·0	1·58	21·5	3·78	34·0	5·98
9·5	1·67	22·0	3·87	34·5	6·07
10·0	1·76	22·5	3·96	35·0	6·16
10·5	1·85	23·0	4·05		
11·0	1·94	23·5	4·14	0·1	0·02
11·5	2·02	24·0	4·22	0·2	0·04
12·0	2·11	24·5	4·31	0·3	0·05
12·5	2·20	25·0	4·40	0·4	0·07
13·0	2·29	25·5	4·49		

* Calculated as Butyric Acid, $C_4H_8O_2 = 88$.

TABLE FOR THE DETERMINATION OF BUTTER-FAT IN MARGARINE.*

Reichert-Wollny Number of the Mixture.	Percentage of Butter-Fat present in the Mixture.
4·0	10
4·3	11
4·6	12
4·9	13
5·2	14
5·5	15
5·9	16
6·2	17
6·5	18
6·8	19
7·1	20

Note.—Since the above was issued margarine manufacturers have largely introduced cocoa-nut oil into their product, 40 per cent. or more being sometimes used. The volatile acids thus derived may cause an unduly high percentage of butter-fat to be recorded (see *The Analyst*, 1904, p. 208).

TABLE SHOWING THE VARIATIONS IN REICHERT-WOLLNY NUMBER, ETC., OF BUTTER AND MARGARINE. †

	Butter.		Margarine.
	Mean.	Variations.	
Reichert-Wollny number	28·4 c.c.	21·2–35 c.c.	0·0–0·3 c.c.
Insoluble fatty acids	87·75%	85·6–89·6%	95–96%
Soluble fatty acids	5·58%	4·6–7·0%	trace
Butyro - refractometer (Zeiss) at 35° C.	46·0	43·8–49	52–56
Iodine absorption	37·4%	31·6–42·0%	50–60%
Sp. gr. 100° F./100°	0·9117	0·9105–·9122	0·901–·903
Potash absorption	22·58%	22·01–22·98%	19·1–19·6%

THE INTERDEPENDENCE OF THE PHYSICAL AND CHEMICAL CRITERIA IN THE ANALYSIS OF BUTTER-FAT.

During 1901–2 over four hundred samples of butter were taken from farms or creameries in various parts of the United Kingdom, including the Orkneys, Shetlands and Hebrides, the samples being specially selected with the view of ascertaining by analysis the extent to which the chemical nature of butter-fat is dependent on the climatic influences to which the cows are exposed, on the nature and amount of the food supplied, and on the breed, period

* From the Report of the official method for determining the percentage of butter-fat in margarine (see *The Analyst*, 1900, p. 310).

† By H. Droop Richmond, see Appendix XXI. to the *Final Report of the Departmental Committee on Butter Regulations*, 1904.

of lactation, and idiosyncrasy of the individual cow. Of the samples collected, 357 were fully analysed in the Government Laboratory, and the results, which are fully recorded in supplements to the report already referred to, form the subject of a paper with the above title* by Dr T. E. Thorpe, C.B., F.R.S. The results are summarized in the subjoined table :—

Butter-fat.	357 samples examined.		
	39 samples (10·9%)	290 samples (81·2%).	28 samples (7·9%).
Reichert - Wollny number . .	22·5 – 24·5	25·5 – 30·5	31·3 – 32·6
Sp. gr. 100° F./100° F.	0·9101 – ·9108	0·9110 – ·9123	0·9125 – ·9130
Saponification equivalent . . .	255·4 – 251·3	251·1 – 242·4	241·5 – 241·2
(Koettstorfer number)	219·3 – 222·8	223·0 – 231·0	231·9 – 232·2
Butyro - refractometer (Zeiss) at 45° C. .	42 – 41·5	41·3 – 39·9	39·7 – 39·4
Soluble acids †% .	4·3 – 4·7	4·8 – 5·7	5·8 – 6·0
Insoluble acids % .	90·1 – 89·4	89·3 – 87·9	87·9 – 87·7

Dr Thorpe makes the following comments :—

"It will be seen that, in a general sense, the relative density of butter-fat increases as the Reichert-Wollny number is augmented.‡ This would, of course, follow from the well-known fact that the glycerides of low molecular weight have a greater density than the glycerides of the higher fatty acids which occur in butter." . . . "Speaking broadly, the variations of the saponification numbers are in inverse relation to those of the Reichert-Wollny values and the relative densities.‡ . . . The Zeiss numbers generally decrease in magnitude as the Reichert-Wollny values increase, but the rate of diminution is not regular." ‡

Board of Agriculture Rules.

Sale of Butter Regulations, 1902.

Where the proportion of water in a sample of butter exceeds 16 per cent., it shall be presumed for the purposes of the Sale of Food and Drugs Acts, 1875 to 1899, until the contrary is proved, that the butter is not genuine by reason of the excessive amount of water therein.

This regulation extends to Great Britain, and came into operation on 15th May 1902.

* *Journ. Chem. Soc.*, 1904, pp. 248–256.

† Calculated as butyric acid.

‡ These relations are deduced from curves plotted from the averages of the various analytical results.

The Departmental Committee on butter regulations, in their Final Report, dated 1st December 1903, recommend :—

(1) That the figure 24, arrived at by the Reichert-Wollny method, should be the limit below which a presumption should be raised that butter is not genuine.

(2) That the use of 10 per cent. of sesamé oil in the manufacture of margarine be made compulsory.

(3) That steps should be taken to obtain international co-operation.

Two members of the Committee, however, favoured the Reichert-Wollny number of 23 instead of 24. A third member, who did not sign the Report of the majority, stated in a separate report that he considered it would be "highly dangerous" to fix any limit at present.

Calculation of the Results of Milk Analyses.

According to the "Sale of Milk Regulations, 1901" (see p. 143), milk is to be presumed not to be genuine if the non-fatty solids fall below 8·5 per cent., or the milk-fat below 3 per cent.

The calculation of the amount of added water in the case of samples whose non-fatty solids fall below the above limit is made as follows :—

Since 8·5 parts of non-fatty solids correspond to 100 parts of genuine (*i.e., presumably* genuine) milk, S parts of non-fatty solids correspond to $\frac{100}{8 \cdot 5} \times S$ of genuine milk; and 100 parts of the watered sample will contain

$$100 - \frac{100\,S}{8 \cdot 5} = \frac{100}{8 \cdot 5}\,(8 \cdot 5 - S) \text{ of added water.}$$

Since log. $\frac{100}{8 \cdot 5} = 1 \cdot 07058$, we have

log. of percentage of added water $= 1 \cdot 07058 +$ log. (8·5 − per cent. of non-fatty solids found).

We will now consider two examples.

	Example I.	Example II.
Non-fatty solids . .	7·60 per cent.	7·89
Fat	2·80 "	2·25

Example I. $8 \cdot 50 - 7 \cdot 60 = 0 \cdot 90$.

$$\begin{array}{ll} & 1 \cdot 07058 \\ \text{log. } 0 \cdot 9 & \bar{1} \cdot 95424 \\ \hline & 1 \cdot 02482 = \text{log. } 10 \cdot 6 \end{array}$$

$\therefore$ at least 10 per cent. of added water.

A mixture of 90 parts of genuine milk and 10 parts of added water should contain $\frac{90}{100} \times 3 = 2 \cdot 7$ per cent. at least of fat. The sample contains 2·8 per cent., and hence contains proportionately a little more fat than that given in the Regulation.

Example II. $8{\cdot}50 - 7{\cdot}89 = 0{\cdot}61$.

$$\begin{array}{rl} & 1{\cdot}07058 \\ \log. 0{\cdot}61 = & \bar{1}{\cdot}78533 \\ \hline & 0{\cdot}85591 \end{array}$$

$0{\cdot}85591 = \log. 7{\cdot}2$ $\therefore$ at least 7 per cent of added water.

A mixture of 93 parts of genuine milk and 7 parts of added water should contain $0{\cdot}93 \times 3 = 2{\cdot}79$ per cent. at least of fat. The sample contains only 2·25 per cent., and is, therefore, $\frac{100\ (2{\cdot}79 - 2{\cdot}25)}{2{\cdot}79} = 19$ per cent. deficient in milk-fat as well.

Note.—The results given above can be expressed in a different way. Thus, in Ex. I. we have 90 parts of genuine milk mixed with 10 parts of water; or to 100 parts of milk 11·1 parts of water have been added—hence, on this view, the sample has been diluted with 11·1 per cent. of added water. Similarly, a milk that consisted of equal parts of milk and water would be said to be diluted with 100 per cent. of added water. Seeing, however, that the real issue at stake is the composition of the article supplied to the purchaser, the statement that a sample of "milk" contains, *e.g.*, 90 per cent. of genuine milk and 10 per cent. of added water is considered decidedly preferable.

Board of Agriculture Rules.

Sale of Milk Regulations, 1901.

Milk.

1. Where a sample of milk (not being milk sold as skimmed, or separated, or condensed, milk) contains less than 3 per cent. of milk-fat, it shall be presumed for the purposes of the Sale of Food and Drugs Acts, 1875 to 1899, until the contrary is proved, that the milk is not genuine, by reason of the abstraction therefrom of milk-fat, or the addition thereto of water.

2. Where a sample of milk (not being milk sold as skimmed, or separated, or condensed, milk) contains less than 8·5 per cent. of milk-solids other than milk-fat, it shall be presumed for the purposes of the Sale of Food and Drugs Acts, 1875 to 1899, until the contrary is proved, that the milk is not genuine, by reason of the abstraction therefrom of milk-solids other than milk-fat, or the addition thereto of water.

Skimmed or Separated Milk.

3. Where a sample of skimmed or separated milk (not being condensed milk) contains less than 9 per cent. of milk-solids, it shall be presumed for the purposes of the Sale of Food and Drugs Acts, 1875 to 1899, until the contrary is proved, that the milk is not genuine, by reason of the abstraction therefrom of milk-solids other than milk-fat, or the addition thereto of water.

The above regulations extend to Great Britain, and came into operation on 1st September 1901.

… THE PERCENTAGE DEFICIENCY OF NON-FATTY SOLIDS … IN MILK IN WHICH THESE ARE BELOW THE LEGAL … OF 8·5 PER CENT.

… Deficiency in N.F.S.	% Non-fatty Solids.	% Deficiency in N.F.S.	% Non-fatty Solids.	% Deficiency in N.F.S.
52·94	5·5	35·29	7·0	17·65
51·76	·6	34·12	·1	16·47
50·59	·7	32·94	·2	15·29
49·41	·8	31·76	·3	14·12
48·24	·9	30·59	·4	12·94
47·06	6·0	29·41	·5	11·76
45·88	·1	28·24	·6	10·59
44·71	·2	27·06	·7	9·41
43·53	·3	25·88	·8	8·24
42·35	·4	24·71	·9	7·06
41·18	·5	23·53	8·0	5·88
40·00	·6	22·35	·1	4·71
39·82	·7	21·18	·2	3·53
37·65	·8	20·00	·3	2·35
36·47	·9	18·82	·4	1·18

·01	·02	·03	·04	·05	·06	·07	08	·09
·12	·23	·35	·47	·59	·71	·82	·94	1·06

…ple of "milk" containing 7·26% of non-fatty solids would …eficiency of 15·29 − ·71 = 14·58%.

…OWING THE DEFICIENCY IN FAT IN CREAMED MILK.

… Deficiency in Fat.	% Milk-fat.	% Deficiency in Fat.	% Milk-fat.	% Deficiency in Fat.
96·67	1·1	63·33	2·1	30·00
93·33	·2	60·00	·2	26·67
90·00	·3	56·67	·3	23·33
86·67	·4	53·33	·4	20·00
83·33	·5	50·00	·5	16·67
80·00	·6	46·67	·6	13·33
76·67	·7	43·33	·7	10·00
73·33	·8	40·00	·8	6·67
70·00	·9	36·67	·9	3·33
66·67	2·0	33·33	…	…

·01	·02	·03	·04	·05	·06	·07	·08	·09
·33	0·67	1·00	1·33	1·67	2·00	2·33	2·67	3·00

MILK ANALYSIS.

Table to find the sp. gr. of Milk at 60° Fah. from its sp. gr. at any Temperature between 50° and 70° Fah. (water=1000).

°Fah.	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035
50	19·2	20·2	21·2	22·2	23·2	24·1	25·1	26·1	27·0	28·0	29·0	29·9	30·9	31·8	32·7	33·6
51	·3	·3	·3	·3	·3	·2	·2	·2	·1	·1	·1	30·0	31·0	·9	·9	·8
52	·4	·3	·3	·3	·3	·3	·2	·2	·2	·2	·1	·1	·1	32·0	33·0	·9
53	·4	·4	·4	·4	·4	·4	·3	·3	·3	·3	·2	·2	·2	·1	·1	34·0
54	·5	·5	·5	·5	·5	·5	·4	·4	·4	·4	·3	·3	·3	·3	·2	·2
55	·6	·6	·6	·6	·6	·6	·5	·5	·5	·5	·4	·4	·4	·4	·3	·3
56	·7	·7	·7	·7	·6	·6	·6	·6	·6	·6	·6	·5	·5	·5	·5	·5
57	·8	·8	·8	·8	·7	·7	·7	·7	·7	·7	·7	·6	·6	·6	·6	·6
58	·9	·9	·9	·8	·8	·8	·8	·8	·8	·8	·8	·8	·7	·7	·7	·7
59	·9	·9	·9	·9	·9	·9	·9	·9	·9	·9	·9	·9	·9	·9	·9	·9
60	20·0	21·0	22·0	23·0	24·0	25·0	26·0	27·0	28·0	29·0	30·0	31·0	32·0	33·0	34·0	35·0
61	·1	·1	·1	·1	·1	·1	·1	·1	·1	·1	·1	·2	·2	·2	·2	·2
62	·2	·2	·2	·2	·2	·2	·2	·3	·3	·3	·3	·3	·3	·3	·3	·3
63	·2	·3	·3	·3	·3	·3	·3	·4	·4	·4	·4	·4	·5	·5	·5	·5
64	·3	·4	·4	·4	·4	·4	·5	·5	·5	·5	·5	·5	·6	·6	·6	·6
65	·4	·5	·5	·5	·5	·5	·6	·6	·6	·6	·7	·7	·7	·8	·8	·8
66	·5	·6	·6	·6	·6	·6	·7	·7	·7	·8	·8	·8	·9	·9	·9	·9
67	·6	·7	·7	·7	·7	·7	·8	·8	·8	·9	·9	32·0	33·0	34·0	35·0	36·1
68	·7	·8	·8	·8	·9	·9	27·0	28·0	29·0	30·1	31·1	·2	·2	·2	·2	·2
69	·9	22·0	23·0	24·0	25·0	26·0	·1	·1	·1	·2	·2	·2	·3	·3	·3	·4
70	21·0	·1	·1	·1	·1	·1	·2	·2	·2	·3	·3	·4	·4	·5	·5	·5

The observed sp. gr. is given at the top of each column, and the number in the column opposite to the temperature at which the sp. gr. was determined added to 1000 gives the sp. gr. at 60° F.

Ex. 1. Milk of which the sp. gr. is 1032 at 54° F. is 1031·3 at 60° F.

Ex. 2. Milk of which the sp. gr. is 1028·6 at 63° F. becomes 1000 + (28·4 + 0·6) = 1029 at 60° F.

Preservatives in Milk and Cream.

The Local Government Board have recently issued a Draft of "The Public Health (Milk and Cream) Regulations, 1912," by which the addition of any preservative substance to milk (including separated, skimmed, condensed, and dried milk), or to cream containing less than 40 per cent. by weight of milk fat, is prohibited. The addition of any thickening substance* to cream, whether containing preservative or not, is also prohibited. These regulations will come into operation on June 1, 1912.

Cream containing 40 per cent. or more by weight of milk fat may contain no preservative substance other than

(i) Boric acid, borax, or a mixture of these preservative substances,—the article to be described, in such cases, as Preserved Cream, and the amount of preservative, calculated as boric acid (H_3BO_3), to be specified on the label thus: "Preserved Cream containing Boric Acid not exceeding — per cent." †

(ii) Hydrogen peroxide, in amount not exceeding 0·1 per cent. by weight—the cream being labelled "Preserved Cream Peroxidised."

These latter Regulations will not come into operation till January 1, 1913.

Quinine.

Hydrochloride of Quinine, $C_{20}H_{24}N_2O_2, HCl, 2H_2O$. $=396·712$

Percentage composition.

$C_{20}H_{24}N_2O_2$	81·73
HCl	9·19
H_2O	9·08
	100·00

Sulphate of Quinine, $2[(C_{20}H_{24}N_2O_2)_2.H_2SO_4], 15H_2O$. $=1763·26$

Percentage composition.

$C_{20}H_{24}N_2O_2$	73·55
H_2SO_4	11·12
H_2O	15·33
	100·00

To convert	Multiplier.	Log. to be added.
$C_{20}H_{24}N_2O_2$ into $C_{20}H_{24}N_2O_2, HCl, 2H_2O$	1·2236	0·087 6462
" " $2[(C_{20}H_{24}N_2O_2)_2.H_2SO_4], 15H_2O$	1·360	0·133 4273

Tincture of Quinine, B.P. 1898, contains 2 grams of hydrochloride of quinine in 100 c.c.

* *i.e.* sucrate of lime, gelatin, starch paste, etc.; but neither cane nor beet sugar shall be regarded as a preservative or as a thickening substance.

† No mention is made of the maximum amount of boric acid that will be allowed.

E. W. T. Jones's Method for the Estimation of Chicory in Mixtures of Coffee and Chicory.

The sample is dried in the water-oven, and 5 grams are weighed into a large porcelain dish. About 200 c.c. of water are added, and boiled for 15 minutes. After allowing a minute or two for settling, the liquid is strained through a piece of copper gauze placed in a funnel into a 250-c.c. measuring flask, care being taken to disturb

(To Face Page 146).

"The Public Health (Milk and Cream) Regulations, 1912," were issued on August 1, 1912. They differ from the Draft, as summarized on page 146, in the following respects :—

For "40 per cent." (of milk fat) read "35 per cent."

For "June 1, 1912" read "October 1, 1912."

Paragraph (ii) should be

(ii) Hydrogen peroxide—the cream being labelled "Preserved Cream (Peroxide)."

$$\cdot 46x = E - 24.$$
$$x = \frac{E - 24.}{\cdot 46}$$

Putting $x = 1$, we find $E = 24{\cdot}46$, and the table on page 148 is in this way easily calculated.

Note.—By the above method E. W. T. Jones obtained the excellent results recorded in *The Analyst*, 1882, 7, 76, in the case of the Birkenhead "Coffee" samples.

Lead in Tartaric and Citric Acids and in Cream of Tartar.

Dr MacFadden, in a Report to the Local Government Board,* recommends the adoption of a limit of 0·002 per cent. (approximately $\frac{1}{7}$th grain per lb.) of lead as impurity in tartaric acid, citric acid, and cream of tartar.

* Report (No. 2) on Lead and Arsenic in Tartaric Acid, Citric Acid and Cream of Tartar, 1907.

Table showing the Percentage of Chicory with Coffee from the Percentage of Aqueous Extract.

Extract per cent.	Chicory per cent.	Extract per cent.	Chicory per cent.	Extract per cent.	Chicory per cent.
24·46	1	40·10	35	55·28	68
·92	2	·56	36	·74	69
25·38	3	41·02	37	56·20	70
·84	4	·48	38	·66	71
26·30	5	·94	39	57·12	72
·76	6	42·40	40	·58	73
27·22	7	·86	41	58·04	74
·68	8	43·32	42	·50	75
28·14	9	·78	43	·96	76
·60	10	44·24	44	59·42	77
29·06	11	·70	45	·88	78
·52	12	45·16	46	60·34	79
·98	13	·62	47	·80	80
30·44	14	46·08	48	61·26	81
·90	15	·54	49	·72	82
31·36	16	47·00	50	62·18	83
·82	17	·46	51	·64	84
32·28	18	·92	52	63·10	85
·74	19	48·38	53	·56	86
33·20	20	·84	54	64·02	87
·66	21	49·30	55	·48	88
34·12	22	·76	56	·94	89
·58	23	50·22	57	65·40	90
35·04	24	·68	58	·86	91
·50	25	51·14	59	66·32	92
·96	26	·60	60	·78	93
36·42	27	52·06	61	67·24	94
·88	28	·52	62	·70	95
37·34	29	·98	63	68·16	96
·80	30	53·44	64	·62	97
38·26	31	·90	65	69·08	98
·72	32	54·36	66	·54	99
39·18	33	·82	67	70·00	100
·64	34				

FOOD PRESERVATIVES.

The Departmental Committee on Food Preservatives appointed in 1899 in their Report,* issued in 1901, make the following recommendations:—

(*a*) That the use of formaldehyde or formalin, or preparations thereof, in food or drinks, be absolutely prohibited, and that salicylic acid be not used in a greater proportion than 1 grain per pint in liquid food and 1 grain per pound in solid food. Its presence in all cases to be declared.

(*b*) That the use of any preservative or colouring matter whatever in milk offered for sale in the United Kingdom be constituted an offence under the Sale of Food and Drugs Acts.†

(*c*) That the only preservative which it shall be lawful to use in cream be boric acid, or mixtures of boric acid and borax, and in amount not exceeding 0·25 per cent. expressed as boric acid. The amount of such preservative to be notified by a label upon the vessel.

(*d*) That the only preservative permitted to be used in butter and margarine be boric acid, or mixtures of boric acid and borax, to be used in proportions not exceeding 0·5 per cent. expressed as boric acid.

(*e*) That in the case of all dietetic preparations intended for the use of invalids or infants, chemical preservatives of all kinds be prohibited.

(*f*) That the use of copper salts in the so-called greening of preserved foods be prohibited.

(*g*) That means be provided either by the establishment of a separate court of reference, or by the imposition of more direct obligation on the Local Government Board, to exercise supervision over the use of preservatives and colouring matters in foods, and to prepare schedules of such as may be considered inimical to the public health.

With regard to the recommendation marked (*f*), Dr Tunnicliffe, a member of the Committee, points out the value of appearance in rendering foods appetising, and recommends that not more than the equivalent of half a grain of metallic copper per pound should be allowed to be added, the actual amount used being declared.

ARSENIC IN FOOD.

In the Final Report of the Royal Commission appointed to inquire into Arsenical Poisoning, issued in November 1903, the Commissioners state (Part VIII., p. 50), that "In our view it would be entirely proper that penalties should be imposed under the Sale of Food and Drugs Acts upon any vendor of beer or any other liquid food, or of any liquid entering into the composition

* *Report of Departmental Committee on Preservatives and Colouring Matters in Food*, 1901, pp. xxx and xxxi.

† See also Circular issued by the Local Government Board, July 11, 1906 (reprinted in *The Analyst*, 1906, **31**, 278).

of food, if that liquid is shown by an adequate test to contain $\frac{1}{100}$th of a grain or more of arsenic in the gallon; and, with regard to solid food—no matter whether it is habitually consumed in large or in small quantities, or whether it is taken by itself (like golden syrup) or mixed with water or other substances (like chicory or 'carnos')—if the substance is shown by an adequate test to contain $\frac{1}{100}$th grain of arsenic or more in the pound."

Note.—In the above "arsenic" is taken to mean *arsenious oxide* (As_4O_6).

Data in Heat and Thermo-Chemistry.

The C.G.S. unit of heat is the calorie, which is the quantity of heat required to raise 1 gram of water through 1° C.

A large or major calorie is the quantity of heat required to raise 1 kilogram of water through 1° C.

A British Thermal Unit (B.T.U.) is the quantity of heat required to raise 1 lb. of water through 1° Fah.

1 (large) calorie = 3·968 B.T.U. (log. 0·59857).

1 B.T.U. = 0·252 (large) calories (log. $\bar{1}$·40143).

The values of the mechanical equivalent of heat, that is, the number of units of mechanical work equivalent to one unit of heat, or Joule's equivalent (designated by the letter J), are usually taken to be as follows:—

777 foot-pounds	are equivalent to	1 B.T.U. (lb. deg. Fah.).
1399 ,,	,, ,,	1 lb. deg. C.
426·3 kilogrammetres	,, ,,	1 kilogram-deg. C. or kilo-calorie.
4·180 joules*	,, ,,	1 gram-deg. C. or calorie.

The water for the heat units is supposed to be taken at 20° C. (68° F.) and the degree of temperature is supposed to be measured by the hydrogen thermometer.

Heat evolved in calories (water-gram-degrees) on burning 1 gram of:—

Hydrogen to water at 0° C.	34000
Carbon to carbon dioxide	8080
,, ,, monoxide	2400
Coal	8300–6400
Anthracite	8000
Coke	7100–6860
Wood (with 20 per cent. water)	2750
,, (air-dried)	2900
,, (dried at 120° C.)	3600
Peat (air-dried)	3000–3500
Lignite	3500–5000

The latent heat of water is 80 (gram-deg. C.) or 144 in B.T.U.

The latent heat of steam is 537 (gram-deg. C.) or 967 in B.T.U.

* The joule is the practical unit of work in the C.G.S. system. It equals 10 million (or 10^7) absolute units of work (ergs).

The Determination of the Calorific Power of Fuel by Thompson's Calorimeter.

Although recent comparative experiments with different types of calorimeter * have conclusively proved the superiority of Mahler's Bomb Calorimeter above all other forms, still, owing to the expense of the instrument, it seems unlikely to come into general use at present. And since Thompson's Calorimeter is so largely used, the following details of manipulation are given, so that the best results the instrument is capable of giving may be obtained.†

In the first place it should be noted that for coals of an anthracitic character, yielding more than 87 per cent. of coke, or for coke itself, Thompson's Calorimeter is not suited as an indicator of their comparative calorific power, for the simple reason that some of the carbon is so graphitic in its nature that it will not burn perfectly when mixed with nitrate and chlorate of potash; but with bituminous and semi-bituminous coals the apparatus yields very satisfactory results.

Preparation of the sample of coal.—Sample the coal until an average portion passes through an 8-mesh sieve. Take about 20 grams of this and run through a 68-mesh sieve, taking care that the whole sample selected is thus treated. Then dry at 100° C., and use the dried coal for making the determination.

Preparation of the oxidizing mixture.—Potassium nitrate and chlorate are used in the proportion of 1 part of nitrate to 3 of chlorate. These are first thoroughly dried, ground separately, and sifted through a 30-mesh sieve—a finer powder being prejudicial. The powders are then mixed in the proportions stated, and kept in a well-stoppered bottle.

Preparation of the wick.—Oxford cotton is soaked in a moderately strong solution of potassium nitrate, and dried. When dry, it should burn a little too quickly. It should then be rubbed between two pieces of cloth until it burns just freely enough. Four cotton strands are twisted together, cut into ¾-inch lengths, thoroughly dried, and put into a bottle.

The process.—Before weighing out the coal, etc., read the temperature of the room, and regulate the temperature of the water used by the following table.

Temperature of room.		Water should be at.	
80° F.	(26·7° C.)	70° F.	(21·1° C.)
72°	(22·2° C.)	64°	(17·8° C.)
67°	(19·4° C.)	60°	(15·6° C.)
60°	(15·6° C.)	54°	(12·2° C.)
55°	(12·8° C.)	50°	(10° C.)
50°	(10° C.)	46°	(7·8° C.)
42°	(5·6° C.)	40°	(4·4° C.)

* See paper by Brame and Cowan, *J.S.C.I.*, 1903, p. 1230.

† The details given are condensed from the valuable paper by J. W. Thomas in the *Chemical News*, 25th March 1881, p. 135, with additions by the author.

Instead of simply filling up to the 29,010 grain mark, it is more accurate to measure out 2 litres, *less* 116 c.c., since 29,010 grains of water occupy 1884 c.c. A tall narrow cylinder with a single mark serves to measure the 116 c.c. to be withdrawn from the second litre before pouring in. Put a thermometer into the water and leave it there while weighing out the coal. 30 grains of the dried coal are intimately mixed with 330 grains of the oxidizing mixture; best with a spatula rather than in a mortar. Introduce the mixture into the cylinder ($3\frac{1}{2}'' \times \frac{3}{4}''$), pressing down in small portions at a time with a test-tube; do not tap. Put in the fuse, opening out its lower end in the mixture. Then read the thermometer, light the fuse and place the cylinder, with its stand and cover, quickly in the jar. The combustion should occupy between one and two minutes. At its conclusion the stopcock is opened and the whole moved up and down in the liquid with the thermometer, the latter being read three or four times, and its maximum reading noted. An example will show the mode of calculating results.

Temperature of room	60° F.
" water after combustion . . .	67·1
" " before combustion . . .	54·4
Increase	12·7
$+\frac{1}{10}$*	1·27
Evaporative power of the coal, *i.e.* number of lb. of water at 212° F. evaporated by 1 lb. of the dried coal	13·97

$13·97 \times 537 = 7502$ calories, *i.e.* grams of water heated 1° C. by 1 gram of the coal.

$13·97 \times 967 = 13509$ British Thermal Units, or number of lb. of water heated through 1° Fah. by 1 lb. of the coal.

The evaporative power of the coal in its original state can be calculated as follows:—

Suppose the above coal to have 11·5 per cent. of moisture,
then 1 lb. contains ·885 lb. of dry coal,
and ·115 lb. of moisture,

$$·885 \times 13·97 = 12·36.$$

The quantity of heat required to raise 0·115 lb. of water from 60° to 212° F., and to convert the boiling water into steam, is

$$(152 + 967) \times ·115 \text{ pound-degree Fah. units,}$$

which has an evaporative power of

$$\frac{1119 \times ·115}{967} = 0·13 \text{ lb.}$$

* An addition of 10 per cent. is made to allow for the heat absorbed by the copper cylinder and stand and for carbon not completely burned. It has been found to be too small in most cases, and an increase to 15 per cent. has been suggested by Scheurer-Kestner.

Hence the evaporative power of the original coal is $12{\cdot}36 - {\cdot}13 = 12{\cdot}23$ lb.

Since $\frac{1119}{967} = 1{\cdot}16$, the amount to be finally deducted is obtained by simply multiplying this number by the amount of water contained in 1 lb. of coal.

When the ultimate analysis of a dry coal is known, the calorific value (in calories) can be *approximately* calculated by the following formula :—

$$Q = \frac{1}{100}\left\{8140\ C + 34500\left(H - \frac{(O+N)-1}{8}\right) + 2220\ S\right\}$$

$$= 81{\cdot}4\ C + 43{\cdot}125\left\{8\ H - (O+N) + 1\right\} + 22{\cdot}2\ S.$$

Thus, the analysis of a *dry* coal gave

C 90·09 ; H 3·85 ; (O+N) 3·61 ; S 0·77.

$$\text{Hence } Q = 81{\cdot}4 \times 90{\cdot}09 + 43{\cdot}125\left\{8 \times 3{\cdot}85 - 3{\cdot}61 + 1\right\} + 22{\cdot}2 \times {\cdot}77$$

$$= 7333 + 1216 + 17$$

$$= 8566$$

Mahler's calorimeter gave 8629 calories.

Electrical Units.

The *ohm* is the resistance offered to an unvarying electric current by a column of mercury at 0° C., 14·4521 grams in mass, of a constant cross-sectional area, and of a length of 106·3 cm.

The *ampere* is represented by the unvarying electric current which, when passed through a 10 per cent. aqueous solution of silver nitrate, deposits silver at the rate of 0·001118 gram per second.

The *volt* is the electrical pressure that, if steadily applied to a conductor whose resistance is one ohm, will produce a current of one ampere, and which is represented by 0·6974 $\left(\frac{1000}{1434}\right)$ of the electrical pressure at 15° C. between the poles of a standard Clark's Cell.

Table of Electro-Chemical Equivalents.

(In grams per coulomb.*)

Hydrogen	0·000010384	Iron (ous)	0·0002902
Potassium	0·0004058	,, (ic)	0·0001935
Sodium	0·0002388	Nickel	0·0003048
Gold	0·0006791	Zinc	0·000337
Silver	0·001118	Lead	0·0010716
Copper (ic)	0·0003281		
,, (ous)	0·0006562	Oxygen	0·00008286
Mercury (ic)	0·0010374	Chlorine	0·0003673
,, (ous)	0·0020748	Iodine	0·001314
Tin (ic)	0·0003058	Bromine	0·0008282
,, (ous)	0·0006116	Nitrogen	0·0000485

* The coulomb is the quantity of electricity conveyed by a current of one ampere in one second (also called an ampere-second).

The values given on p. 153 are obtained by multiplying 0·000010384 (the electro-chemical equivalent of hydrogen) by the fraction $\frac{\text{atomic weight}}{\text{valency}}$ of each element.

The prefix meg- means a million times the unit to which it is prefixed.

The prefix micro- means a millionth part of the unit to which it is prefixed.

Thus a megohm is a million ohms, and 1 microvolt is a millionth of a volt.

The watt is the power of a current of 1 ampere flowing under a pressure of 1 volt. It equals $\frac{1}{746}$ of one horse-power.

1 kilowatt = 1000 watts = 44,240 ft.-lb. per min.
= 1·34 horse-power.

1 electrical horse-power = 746 watts = 33,000 ft.-lb. per min.

1 B.T.U. = 3,600,000 watt-seconds, or $3{\cdot}6 \times 10^6$ watt-seconds.

1 kilowatt-hour = 1·34 horse-power hours.

1 French or metric horse-power = 75 kilogrammetres per sec.
= 32,549 ft.-lb. per min.
= 736 watts.
= 0·9863 British horse-power.

1 British horse-power = 1·01385 French horse-power (force de cheval).

Board of Trade Unit (B.T.U.). For commercial purposes electrical energy is measured in units of 1000 watt-hours each, known as Board of Trade units.

$$1 \text{ B.T.U.} = \frac{1000}{746} = 1\tfrac{1}{3} \text{ horse power-hours.}$$

Rules for the Conversion of Thermometric Degrees from one Scale into Another.

To Convert	Rules.
° F. into ° C.	First subtract 32, then multiply by 5 and divide by 9.
° F. into ° R.	First subtract 32, then multiply by 4 and divide by 9.
° C. into ° F.	Multiply by 9 and divide by 5, then add 32.
° C. into ° R.	Multiply by 4 and divide by 5.
° R. into ° F.	Multiply by 9 and divide by 4, then add 32.
° R. into ° C.	Multiply by 5 and divide by 4.

Note.—Perhaps the simplest rule for the conversion of °C. into °F. is the following :—

Double the number of degrees, subtract one-tenth, then add 32.

Thus

90° C. 90 × 2 = 180 − 18 = 162 + 32 = 194° F.

Conversion of the different Thermometric Scales.

Table I.

Fahr.	Reaum.	Cent.	Fahr.	Reaum.	Cent.	Fahr.	Reaum.	Cent.
500	208	260	452	186·7	233·3	404	165·3	206·7
499	207·6	259·4	451	186·2	232·8	403	164·9	206·1
498	207·1	258·9	450	185·8	232·2	402	164·4	205·6
497	206·7	258·3	449	185·3	231·7	401	164	205
496	206·2	257·8	448	184·9	231·1	400	163·6	204·4
495	205·8	257·2	447	184·4	230·6	399	163·1	203·9
494	205·3	256·7	446	184	230	398	162·7	203·3
493	204·9	256·1	445	183·6	229·4	397	162·2	202·8
492	204·4	255·6	444	183·1	228·9	396	161·8	202·2
491	204	255	443	182·7	228·3	395	161·3	201·7
490	203·6	254·4	442	182·2	227·8	394	160·9	201·1
489	203·1	253·9	441	181·8	227·2	393	160·4	200·6
488	202·7	253·3	440	181·3	226·7	392	160	200
487	202·2	252·8	439	180·9	226·1	391	159·6	199·4
486	201·8	252·2	438	180·4	225·6	390	159·1	198·9
485	201·3	251·7	437	180	225	389	158·7	198·3
484	200·9	251·1	436	179·6	224·4	388	158·2	197·8
483	200·4	250·6	435	179·1	223·9	387	157·8	197·2
482	200	250	434	178·7	223·3	386	157·3	196·7
481	199·6	249·4	433	178·2	222·8	385	156·9	196·1
480	199·1	248·9	432	177·8	222·2	384	156·4	195·6
479	198·7	248·3	431	177·3	221·7	383	156	195
478	198·2	247·8	430	176·9	221·1	382	155·6	194·4
477	197·8	247·2	429	176·4	220·6	381	155·1	193·9
476	197·3	246·7	428	176	220	380	154·7	193·3
475	196·9	246·1	427	175·6	219·4	379	154·2	192·8
474	196·4	245·6	426	175·1	218·9	378	153·8	192·2
473	196	245	425	174·7	218·3	377	153·3	191·7
472	195·6	244·4	424	174·2	217·8	376	152·9	191·1
471	195·1	243·9	423	173·8	217·2	375	152·4	190·6
470	194·7	243·3	422	173·3	216·7	374	152	190
469	194·2	242·8	421	172·9	216·1	373	151·6	189·4
468	193·8	242·2	420	172·4	215·6	372	151·1	188·9
467	193·3	241·7	419	172	215	371	150·7	188·3
466	192·9	241·1	418	171·6	214·4	370	150·2	187·8
465	192·4	240·6	417	171·1	213·9	369	149·8	187·2
464	192	240	416	170·7	213·3	368	149·3	186·7
463	191·6	239·4	415	170·2	212·8	367	148·9	186·1
462	191·1	238·9	414	169·8	212·2	366	148·4	185·6
461	190·7	238·3	413	169·3	211·7	365	148	185
460	190·2	237·8	412	168·9	211·1	364	147·6	184·4
459	189·8	237·2	411	168·4	210·6	363	147·1	183·9
458	189·3	236·7	410	168	210	362	146·7	183·3
457	188·9	236·1	409	167·6	209·4	361	146·2	182·8
456	188·4	235·6	408	167·1	208·9	360	145·8	182·2
455	188	235	407	166·7	208·3	359	145·3	181·7
454	187·6	234·4	406	166·2	207·8	358	144·9	181·1
453	187·1	233·9	405	165·8	207·2	357	144·4	180·6

Conversion of the different Thermometric Scales.

Table I.—*continued.*

Fahr.	Reaum.	Cent.	Fahr.	Reaum.	Cent.	Fahr.	Reaum.	Cent.
356	144	180	308	122·7	153·3	260	101·3	126·7
355	143·6	179·4	307	122·2	152·8	259	100·9	126·1
354	143·1	178·9	306	121·8	152·2	258	100·4	125·6
353	142·7	178·3	305	121·3	151·7	257	100	125
352	142·2	177·8	304	120·9	151·1	256	99·6	124·4
351	141·8	177·2	303	120·4	150·6	255	99·1	123·9
350	141·3	176·7	302	120	150	254	98·7	123·3
349	140·9	176·1	301	119·6	149·4	253	98·2	122·8
348	140·4	175·6	300	119·1	148·9	252	97·8	122·2
347	140	175	299	118·7	148·3	251	97·3	121·7
346	139·6	174·4	298	118·2	147·8	250	96·9	121·1
345	139·1	173·9	297	117·8	147·2	249	96·4	120·6
344	138·7	173·3	296	117·3	146·7	248	96	120
343	138·2	172·8	295	116·9	146·1	247	95·6	119·4
342	137·8	172·2	294	116·4	145·6	246	95·1	118·9
341	137·3	171·7	293	116	145	245	94·7	118·3
340	136·9	171·1	292	115·6	144·4	244	94·2	117·8
339	136·4	170·6	291	115·1	143·9	243	93·8	117·2
338	136	170	290	114·7	143·3	242	93·3	116·7
337	135·6	169·4	289	114·2	142·8	241	92·9	116·1
336	135·1	168·9	288	113·8	142·2	240	92·4	115·6
335	134·7	168·3	287	113·3	141·7	239	92	115
334	134·2	167·8	286	112·9	141·1	238	91·6	114·4
333	133·8	167·2	285	112·4	140·6	237	91·1	113·9
332	133·3	166·7	284	112	140	236	90·7	113·3
331	132·9	166·1	283	111·6	139·4	235	90·2	112·8
330	132·4	165·6	282	111·1	138·9	234	89·8	112·2
329	132	165	281	110·7	138·3	233	89·3	111·7
328	131·6	164·4	280	110·2	137·8	232	88·9	111·1
327	131·1	163·9	279	109·8	137·2	231	88·4	110·6
326	130·7	163·3	278	109·3	136·7	230	88	110
325	130·2	162·8	277	108·9	136·1	229	87·6	109·4
324	129·8	162·2	276	108·4	135·6	228	87·1	108·9
323	129·3	161·7	275	108	135	227	86·7	108·3
322	128·9	161·1	274	107·6	134·4	226	86·2	107·8
321	128·4	160·6	273	107·1	133·9	225	85·8	107·2
320	128	160	272	106·7	133·3	224	85·3	106·7
319	127·6	159·4	271	106·2	132·8	223	84·9	106·1
318	127·1	158·9	270	105·8	132·2	222	84·4	105·6
317	126·7	158·3	269	105·3	131·7	221	84	105
316	126·2	157·8	268	104·9	131·1	220	83·6	104·4
315	125·8	157·2	267	104·4	130·6	219	83·1	103·9
314	125·3	156·7	266	104	130	218	82·7	103·3
313	124·9	156·1	265	103·6	129·4	217	82·2	102·8
312	124·4	155·6	264	103·1	128·9	216	81·8	102·2
311	124	155	263	102·7	128·3	215	81·3	101·7
310	123·6	154·4	262	102·2	127·8	214	80·9	101·1
309	123·1	153·9	261	101·8	127·2	213	80·4	100·6

Conversion of the different Thermometric Scales.

Table I.—*continued.*

Fahr.	Reaum.	Cent.	Fahr.	Reaum.	Cent.	Fahr.	Reaum.	Cent.
212	80·0	100·0	164	58·7	73·3	116	37·3	46·7
211	79·6	99·4	163	58·2	72·8	115	36·9	46·1
210	79·1	98·9	162	57·8	72·2	114	36·4	45·6
209	78·7	98·3	161	57·3	71·7	113	36·0	45·0
208	78·2	97·8	160	56·9	71·1	112	35·6	44·4
207	77·8	97·2	159	56·4	70·6	111	35·1	43·9
206	77·3	96·7	158	56·0	70·0	110	34·7	43·3
205	76·9	96·1	157	55·6	69·4	109	34·2	42·8
204	76·4	95·6	156	55·1	68·9	108	33·8	42·2
203	76·0	95·0	155	54·7	68·3	107	33·3	41·7
202	75·6	94·4	154	54·2	67·8	106	32·9	41·1
201	75·1	93·9	153	53·8	67·2	105	32·4	40·6
200	74·7	93·3	152	53·3	66·7	104	32·0	40·0
199	74·2	92·8	151	52·9	66·1	103	31·6	39·4
198	73·8	92·2	150	52·4	65·6	102	31·1	38·9
197	73·3	91·7	149	52·0	65·0	101	30·7	38·3
196	72·9	91·1	148	51·6	64·4	100	30·2	37·8
195	72·4	90·6	147	51·1	63·9	99	29·8	37·2
194	72·0	90·0	146	50·7	63·3	98	29·3	36·7
193	71·6	89·4	145	50·2	62·8	97	28·9	36·1
192	71·1	88·9	144	49·8	62·2	96	28·4	35·6
191	70·7	88·3	143	49·3	61·7	95	28·0	35·0
190	70·2	87·8	142	48·9	61·1	94	27·6	34·4
189	69·8	87·2	141	48·4	60·6	93	27·1	33·9
188	69·3	86·7	140	48·0	60·0	92	26·7	33·3
187	68·9	86·1	139	47·6	59·4	91	26·2	32·8
186	68·4	85·6	138	47·1	58·9	90	25·8	32·2
185	68·0	85·0	137	46·7	58·3	89	25·3	31·7
184	67·6	84·4	136	46·2	57·8	88	24·9	31·1
183	67·1	83·9	135	45·8	57·2	87	24·4	30·6
182	66·7	83·3	134	45·3	56·7	86	24·0	30·0
181	66·2	82·8	133	44·9	56·1	85	23·6	29·4
180	65·8	82·2	132	44·4	55·6	84	23·1	28·9
179	65·3	81·7	131	44·0	55·0	83	22·7	28·3
178	64·9	81·1	130	43·6	54·4	82	22·2	27·8
177	64·4	80·6	129	43·1	53·9	81	21·8	27·2
176	64·0	80·0	128	42·7	53·3	80	21·3	26·7
175	63·6	79·4	127	42·2	52·8	79	20·9	26·1
174	63·1	78·9	126	41·8	52·2	78	20·4	25·6
173	62·7	78·3	125	41·3	51·7	77	20·0	25·0
172	62·2	77·8	124	40·9	51·1	76	19·6	24·4
171	61·8	77·2	123	40·4	50·6	75	19·1	23·9
170	61·3	76·7	122	40·0	50·0	74	18·7	23·3
169	60·9	76·1	121	39·6	49·4	73	18·2	22·8
168	60·4	75·6	120	39·1	48·9	72	17·8	22·2
167	60·0	75·0	119	38·7	48·3	71	17·3	21·7
166	59·6	74·4	118	38·2	47·8	70	16·9	21·1
165	59·1	73·9	117	37·8	47·2	69	16·4	20·6

Conversion of the different Thermometric Scales.

Table I.—*continued.*

Fahr.	Reaum.	Cent.	Fahr.	Reaum.	Cent.	Fahr.	Reaum.	Cent.
68	16·0	20·0	34	0·9	1·1	0	−14·2	−17·8
67	15·6	19·4	33	0·4	0·6	−1	−14·7	−18·3
66	15·1	18·9	32	0·0	0·0	−2	−15·1	−18·9
65	14·7	18·3	31	−0·4	−0·6	−3	−15·6	−19·4
64	14·2	17·8	30	−0·9	−1·1	−4	−16·0	−20·0
63	13·8	17·2	29	−1·3	−1·7	−5	−16·4	−20·6
62	13·3	16·7	28	−1·8	−2·2	−6	−16·9	−21·1
61	12·9	16·1	27	−2·2	−2·8	−7	−17·3	−21·7
60	12·4	15·6	26	−2·7	−3·3	−8	−17·8	−22·2
59	12·0	15·0	25	−3·1	−3·9	−9	−18·2	−22·8
58	11·6	14·4	24	−3·6	−4·4	−10	−18·7	−23·3
57	11·1	13·9	23	−4·0	−5·0	−11	−19·1	−23·9
56	10·7	13·3	22	−4·4	−5·6	−12	−19·6	−24·4
55	10·2	12·8	21	−4·9	−6·1	−13	−20·0	−25·0
54	9·8	12·2	20	−5·3	−6·7	−14	−20·4	−25·6
53	9·3	11·7	19	−5·8	−7·2	−15	−20·9	−26·1
52	8·9	11·1	18	−6·2	−7·8	−16	−21·3	−26·7
51	8·4	10·6	17	−6·7	−8·3	−17	−21·8	−27·2
50	8·0	10·0	16	−7·1	−8·9	−18	−22·2	−27·8
49	7·6	9·4	15	−7·6	−9·5	−19	−22·7	−28·3
48	7·1	8·9	14	−8·0	−10·0	−20	−23·1	−28·9
47	6·7	8·3	13	−8·4	−10·6	−21	−23·6	−29·4
46	6·2	7·8	12	−8·9	−11·1	−22	−24·0	−30·0
45	5·8	7·2	11	−9·3	−11·7	−23	−24·4	−30·6
44	5·3	6·7	10	−9·8	−12·2	−24	−24·9	−31·1
43	4·9	6·1	9	−10·2	−12·8	−25	−25·3	−31·7
42	4·4	5·6	8	−10·7	−13·3	−26	−25·8	−32·2
41	4·0	5·0	7	−11·1	−13·9	−27	−26·2	−32·8
40	3·6	4·4	6	−11·6	−14·4	−28	−26·7	−33·3
39	3·1	3·9	5	−12·0	−15·0	−29	−27·1	−33·9
38	2·7	3·3	4	−12·4	−15·6	−30	−27·6	−34·4
37	2·2	2·8	3	−12·9	−16·1	−31	−28·0	−35·0
36	1·8	2·2	2	−13·3	−16·7			
35	1·3	1·7	1	−13·8	−17·2			

Conversion of the different Thermometric Scales.

Table II.

Cent.	Reaum.	Fahr.	Cent.	Reaum.	Fahr.	Cent.	Reaum.	Fahr.
260	208	500	252	201·6	485·6	244	195·2	471·2
259	207·2	498·2	251	200·8	483·8	243	194·4	469·4
258	206·4	496·4	250	200	482	242	193·6	467·6
257	205·6	494·6	249	199·2	480·2	241	192·8	465·8
256	204·8	492·8	248	198·4	478·4	240	192	464
255	204	491	247	197·6	476·6	239	191·2	462·2
254	203·2	489·2	246	196·8	474·8	238	190·4	460·4
253	202·4	487·4	245	196	473	237	189·6	458·6

Conversion of the different Thermometric Scales.

Table II.—*continued.*

Cent.	Reaum.	Fahr.	Cent.	Reaum.	Fahr.	Cent.	Reaum.	Fahr.
236	188·8	456·8	188	150·4	370·4	140	112	284
235	188	455	187	149·6	368·6	139	111·2	282·2
234	187·2	453·2	186	148·8	366·8	138	110·4	280·4
233	186·4	451·4	185	148	365	137	109·6	278·6
232	185·6	449·6	184	147·2	363·2	136	108·8	276·8
231	184·8	447·8	183	146·4	361·4	135	108	275
230	184	446	182	145·6	359·6	134	107·2	273·2
229	183·2	444·2	181	144·8	357·8	133	106·4	271·4
228	182·4	442·4	180	144	356	132	105·6	269·6
227	181·6	440·6	179	143·2	354·2	131	104·8	267·8
226	180·8	438·8	178	142·4	352·4	130	104	266
225	180	437	177	141·6	350·6	129	103·2	264·2
224	179·2	435·2	176	140·8	348·8	128	102·4	262·4
223	178·4	433·4	175	140	347	127	101·6	260·6
222	177·6	431·6	174	139·2	345·2	126	100·8	258·8
221	176·8	429·8	173	138·4	343·4	125	100	257
220	176	428	172	137·6	341·6	124	99·2	255·2
219	175·2	426·2	171	136·8	339·8	123	98·4	253·4
218	174·4	424·4	170	136	338	122	97·6	251·6
217	173·6	422·6	169	135·2	336·2	121	96·8	249·8
216	172·8	420·8	168	134·4	334·4	120	96	248
215	172	419	167	133·6	332·6	119	95·2	246·2
214	171·2	417·2	166	132·8	330·8	118	94·4	244·4
213	170·4	415·4	165	132	329	117	93·6	242·6
212	169·6	413·6	164	131·2	327·2	116	92·8	240·8
211	168·8	411·8	163	130·4	325·4	115	92	239
210	168	410	162	129·6	323·6	114	91·2	237·2
209	167·2	408·2	161	128·8	321·8	113	90·4	235·4
208	166·4	406·4	160	128	320	112	89·6	233·6
207	165·6	404·6	159	127·2	318·2	111	88·8	231·8
206	164·8	402·8	158	126·4	316·4	110	88	230
205	164	401	157	125·6	314·6	109	87·2	228·2
204	163·2	399·2	156	124·8	312·8	108	86·4	226·4
203	162·4	397·4	155	124	311	107	85·6	224·6
202	161·6	395·6	154	123·2	309·2	106	84·8	222·8
201	160·8	393·8	153	122·4	307·4	105	84	221
200	160	392	152	121·6	305·6	104	83·2	219·2
199	159·2	390·2	151	120·8	303·8	103	82·4	217·4
198	158·4	388·4	150	120	302	102	81·6	215·6
197	157·6	386·6	149	119·2	300·2	101	80·8	213·8
196	156·8	384·8	148	118·4	298·4	100	80	212
195	156	383	147	117·6	296·6	99	79·2	210·2
194	155·2	381·2	146	116·8	294·8	98	78·4	208·4
193	154·4	379·4	145	116	293	97	77·6	206·6
192	153·6	377·6	144	115·2	291·2	96	76·8	204·8
191	152·8	375·8	143	114·4	289·4	95	76	203
190	152	374	142	113·6	287·6	94	75·2	201·2
189	151·2	372·2	141	112·8	285·8	93	74·4	199·4

Conversion of the different Thermometric Scales.

Table II.—*continued.*

Cent.	Reaum.	Fahr.	Cent.	Reaum.	Fahr.	Cent.	Reaum.	Fahr.
92	73·6	197·6	49	39·2	120·2	6	4·8	42·8
91	72·8	195·8	48	38·4	118·4	5	4	41
90	72	194	47	37·6	116·6	4	3·2	39·2
89	71·2	192·2	46	36·8	114·8	3	2·4	37·4
88	70·4	190·4	45	36	113	2	1·6	35·6
87	69·6	188·6	44	35·2	111·2	1	0·8	33·8
86	68·8	186·8	43	34·4	109·4	0	0	32
85	68	185	42	33·6	107·6	-1	-0·8	30·2
84	67·2	183·2	41	32·8	105·8	-2	-1·6	28·4
83	66·4	181·4	40	32	104	-3	-2·4	26·6
82	65·6	179·6	39	31·2	102·2	-4	-3·2	24·8
81	64·8	177·8	38	30·4	100·4	-5	-4	23
80	64	176	37	29·6	98·6	-6	-4·8	21·2
79	63·2	174·2	36	28·8	96·8	-7	-5·6	19·4
78	62·4	172·4	35	28	95	-8	-6·4	17·6
77	61·6	170·6	34	27·2	93·2	-9	-7·2	15·8
76	60·8	168·8	33	26·4	91·4	-10	-8	14
75	60	167	32	25·6	89·6	-11	-8·8	12·2
74	59·2	165·2	31	24·8	87·8	-12	-9·6	10·4
73	58·4	163·4	30	24	86	-13	-10·4	8·6
72	57·6	161·6	29	23·2	84·2	-14	-11·2	6·8
71	56·8	159·8	28	22·4	82·4	-15	-12	5
70	56	158	27	21·6	80·6	-16	-12·8	3·2
69	55·2	156·2	26	20·8	78·8	-17	-13·6	1·4
68	54·4	154·4	25	20	77	-18	-14·4	-0·4
67	53·6	152·6	24	19·2	75·2	-19	-15·2	-2·2
66	52·8	150·8	23	18·4	73·4	-20	-16	-4
65	52	149	22	17·6	71·6	-21	-16·8	-5·8
64	51·2	147·2	21	16·8	69·8	-22	-17·6	-7·6
63	50·4	145·4	20	16	68	-23	-18·4	-9·4
62	49·6	143·6	19	15·2	66·2	-24	-19·2	-11·2
61	48·8	141·8	18	14·4	64·4	-25	-20	-13
60	48	140	17	13·6	62·6	-26	-20·8	-14·8
59	47·2	138·2	16	12·8	60·8	-27	-21·6	-16·6
58	46·4	136·4	15	12	59	-28	-22·4	-18·4
57	45·6	134·6	14	11·2	57·2	-29	-23·2	-20·2
56	44·8	132·8	13	10·4	55·4	-30	-24	-22
55	44	131	12	9·6	53·6	-31	-24·8	-23·8
54	43·2	129·2	11	8·8	51·8	-32	-25·6	-25·6
53	42·4	127·4	10	8	50	-33	-26·4	-27·4
52	41·6	125·6	9	7·2	48·2	-34	-27·2	-29·2
51	40·8	123·8	8	6·4	46·4	-35	-28	-31
50	40	122	7	5·6	44·6			

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